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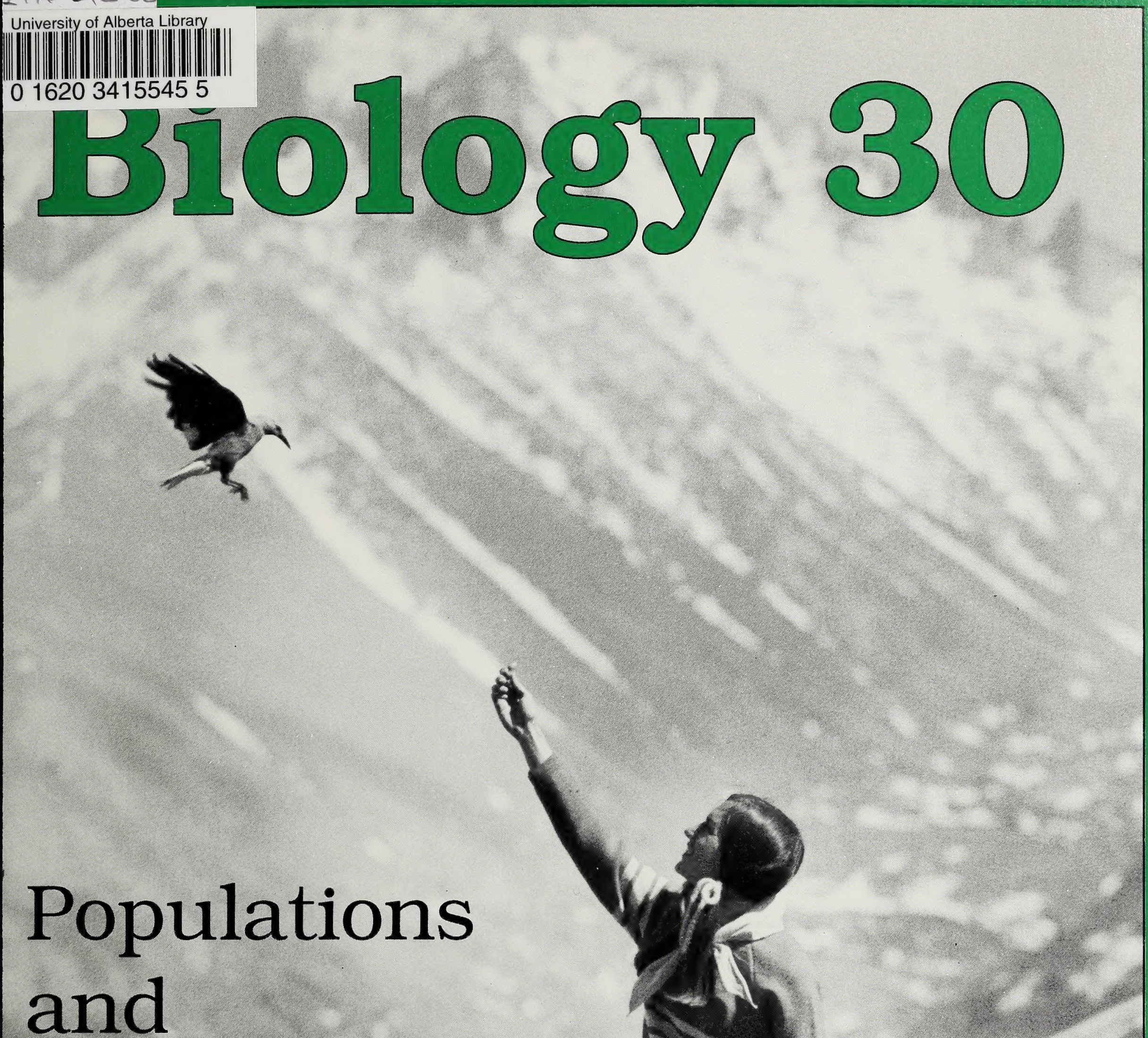

Biology 30

Populations and Communities

Module 7

Distance Learning

Alberta
EDUCATION

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Biology 30

Module 7

Populations and Communities

Distance Learning

Alberta
EDUCATION

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Other	

Biology 30
Student Module
Module 7
Populations and Communities
Alberta Distance Learning Centre
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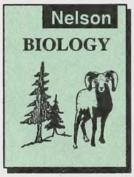
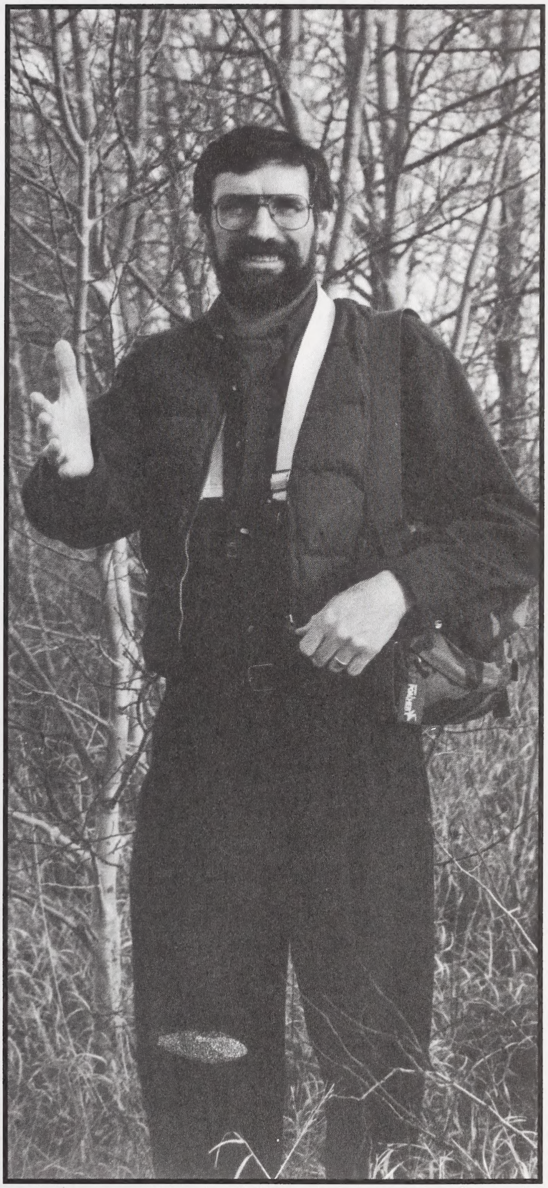
Welcome to Module 7

We hope you'll enjoy your study of *Populations and Communities.* Remember, to make your learning a bit easier, several videocassettes and laser videodiscs are referred to throughout the modules. Your textbook, *Nelson Biology*, will enhance your studies.



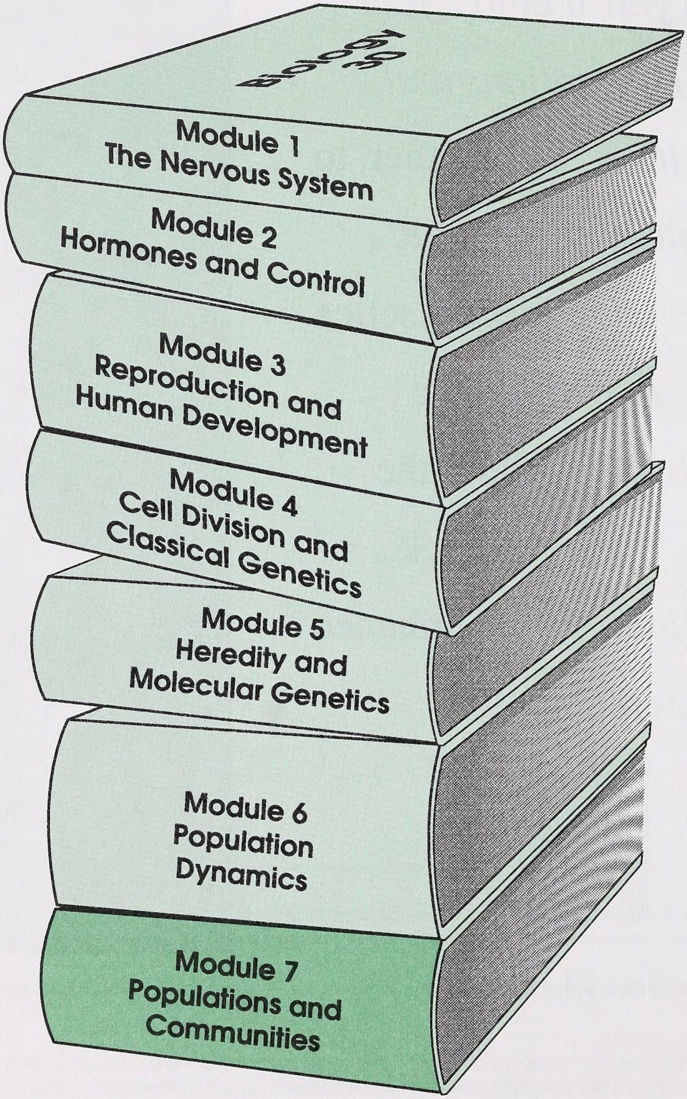
Good Luck!



COURSE OVERVIEW

This course contains seven modules. The module you are working in is highlighted in a darker colour.

Biology 30



MODULE

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MODULE OVERVIEW

Have you been fortunate enough to visit a tropical island? Imagine for a moment Hawaii or Fiji. It's hot and humid. Colourful birds fly out of the jungle growth, past the palm trees, and down a white sandy beach – a paradise, at least in your mind. It wasn't always like this. Once upon a time, perhaps millions of years ago, that very spot in the ocean was just that, a spot in the ocean. Suddenly smoke and ash exploded from the quiet surface. Water boiled into clouds of steam as hot lava met cool blue sea. After a time the lava cooled and formed solid rock. Land existed where none had been before. But it's a long way from bare rock to the tropical paradise you were thinking about a moment ago. Where did the life come from? How did the island change? Why did life form the way it did? Is change still occurring?

Module 7 won't tell you how to make a tropical paradise out of bare rock, but you will learn about populations and communities and how they change in a pattern called succession. You'll study how populations influence one another and how biologists monitor and measure changes. You'll come to understand some natural processes that affect life on Earth, including humans, and develop an appreciation for the fragile and changing biosphere.

As the last module in your Biology 30 course, this module concludes with preparation for your final test and the provincial diploma examination.

Module 7
Populations and Communities

Section 1
Populations

Section 2
Succession

Evaluation

Your mark in this module will be determined by how well you complete the assignments at the end of each section. You must complete all assignments. In this module you are expected to complete two assignments. The mark distribution is as follows:

Section 1 Assignment	**60 marks**
Section 2 Assignment	**40 marks**
TOTAL	**100 marks**

When doing your assignments, work slowly and carefully. If you are having difficulties, go back and review the appropriate section.

Read all parts of your assignment carefully. Plan and do your rough work on your own paper. Revise and edit your responses; then set up your final copy for submission on your own paper. Lined looseleaf is recommended. Make sure your answers are neat and organized, with wide left margins and space for teacher comments after each assignment.

Response Page Setup

When you see this icon, ideas and details are provided to help you set up and organize your answer in a certain way.

Before submitting your responses, be sure to proofread them carefully to ensure they say what you want, that they are neat and clear, and that they are complete and missing no material.

You will be submitting **only** your **assignment response pages** for evaluation.

It is important to number and clearly identify each page with this information placed at the top.

Biology 30 – Module 7   Section # Assignment   Page #   Name and ID #

Notice that for some assignment questions two marks are given for communication. This is indicated at the end of a question. For two marks your response should clearly and logically answer the question and show strong linkages between cause and effect. Your answer should consist of complete sentences and use appropriate scientific terminology. Diagrams may be an appropriate part of your answer. An answer that requires more than one reading to be understood because it has only weak linkages between cause and effect and contains inconsistencies may only be awarded one mark or less.

SECTION 1

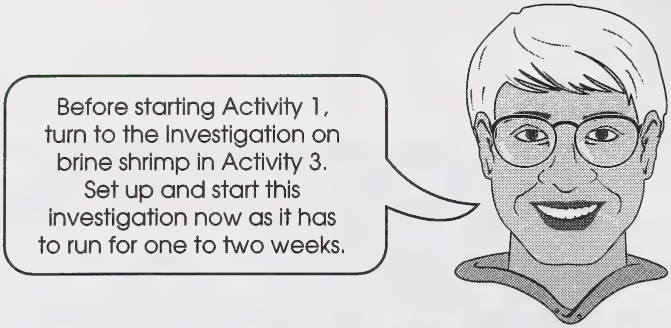
Populations

Have you ever wondered how many people the Earth can support? Overpopulation doesn't seem like a big concern to people who live in Alberta where there is plenty of empty space. Consider though that the population of the planet in the mid-1990s is close to 6 billion. At this current rate of growth it is predicted that the population will reach 9 billion by the year 2010. Experts argue about the maximum number of people the planet can support. What must be considered are the consequences of this remarkably fast growth and what will occur if the Earth's carrying capacity is ever reached.

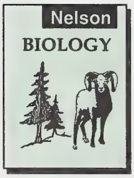
In this section you will learn about the factors that affect population growth and how growth patterns develop. You will analyse how populations change by studying and producing population graphs. An examination of the growth of the human population will conclude the section.

ACTIVITY

1 Describing Populations


Before starting Activity 1, turn to the Investigation on brine shrimp in Activity 3. Set up and start this investigation now as it has to run for one to two weeks.

Are you aware of the rabbit problem in Australia? You wouldn't have seen any rabbits in Australia if you had been there before 1859. But just six years later there were thousands of rabbits everywhere. From only twelve pairs of rabbits introduced by English immigrants to make Australia seem more like "the old country," an incredible population explosion among rabbits occurred. Today, areas in Australia are overrun by thousands, perhaps millions, of rabbits. The rabbit population is out of control.



In this activity you will examine factors that normally control population size, as well as factors that allowed the population of rabbits to flourish.

To introduce this activity and to review the importance of populations and communities which you learned about in Biology 20, read pages 576 and 577 in your text. Then answer the following questions.

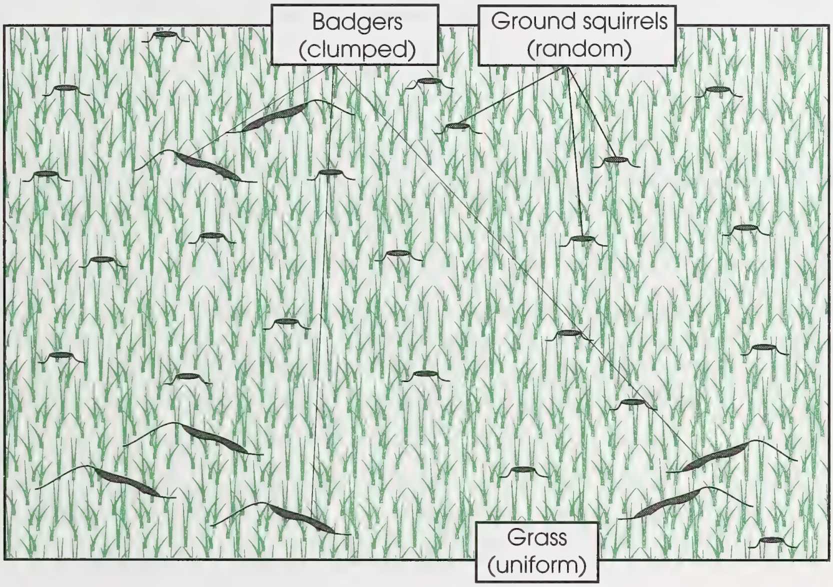
1. Do Review questions 1 and 2 on page 581.

So now you know that a population is a group of individuals of the same species, living at the same time in the same place. But what is meant by the "same place"? To find out, read pages 577 to 578 on habitats, geographic range, and the ecological niche. When you have finished reading, answer the following questions.

2. Do Review question 3 on page 581.

3. Do Review question 4 on page 582.

Some populations within a community are evenly distributed due to their ecological niche. Other populations in the same community may have a different distribution pattern. Consider a field of grass with a population of ground squirrels and badgers. The grass might be evenly distributed. The ground squirrels and badgers would likely be randomly distributed or found in clumps.

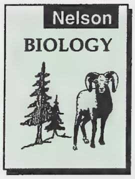


To discover how populations can be distributed, read pages 578 to 579 on distribution of populations and then answer the following questions.

4. Do Review questions 5 and 6 found on page 582.

Check your answers by turning to the Appendix, Section 1: Activity 1.

You should now have an understanding of populations, their niches, as well as their distribution patterns. You are now ready to examine the size and density of populations.



Read pages 580 to 581 on size and density of populations and how to determine changes in population density and then answer the following questions.

5. Develop a statement of population size for the area where you live.

Population size becomes particularly significant when space is considered. Numbers of individuals and area occupied can be used to find density.

Number of individuals
in the population
↓
Density of the population → $D = N/S$
↑
Area the individuals
occupy

Population density could be expressed as *Dp*. Area could be *A* or an *S* for space or *V* for volume.

Science Skills

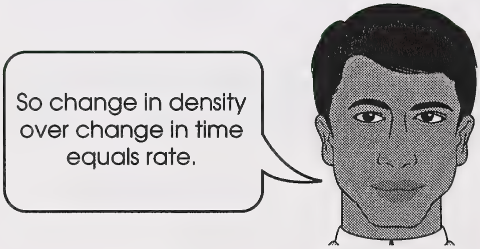
☐ A. Initiating
☐ B. Collecting
☐ C. Organizing
☑ D. Analysing
☐ E. Synthesizing
☑ F. Evaluating

6. What does population density describe?

7. Do Review questions 7 and 8 found on page 582.

As organisms live and die, population density may change. The change in density may be slow or fast depending on many factors and so you can find a rate of change.

Change in density from the
later date to the earlier date
↓
Rate of change in a population → $R = \Delta D / \Delta t$
↑
Change in time from the later
date to the earlier date


So change in density over change in time equals rate.

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☑ D. Analysing
- ☐ E. Synthesizing
- ☑ F. Evaluating

8. Do Review question 9 found on page 582.

Check your answers by turning to the Appendix, Section 1: Activity 1.

Dynamic Equilibrium

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Populations may change in both size and density. What causes these changes to occur? How will these changes affect other populations? The key to understanding population change is to examine the factors that affect population growth. To examine these factors and to investigate how populations tend to remain relatively stable, read pages 582 and 583 and then answer the following questions.

9. List the four factors that influence population size and state whether the factor causes the population to increase or decrease. Notice how these factors are used to calculate population growth (PG).

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☑ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

10. Do Review questions 10 to 12 found on page 589.

Check your answers by turning to the Appendix, Section 1: Activity 1.

Growth Curves

Populations that are in dynamic equilibrium are often studied through data collected regarding their size and density. This information is organized in graphic form to produce growth curves. When constructing a growth curve, scientists and students must be able to interpret the information in the same manner.

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Growth curves for a closed population will follow a particular pattern because the factors of immigration and emigration are no longer involved in determining the population's size. To discover what this pattern is, read pages 583 to 585 on growth curves for closed populations; then answer the following questions.

11. Do Review question 13 found on page 589.

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☑ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

12. In Review question 10 on page 589, the rate of population growth for puffins was +10%. Using this annual rate of growth, calculate the puffin population in 1991 and 1992.

How sure can you be that the population will reach the values obtained in question 12?

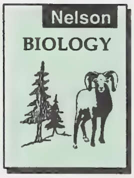
13. Predict why a population may or may not behave normally.

Check your answers by turning to the Appendix, Section 1: Activity 1.

ACTIVITY

2 Studying a New Population

In the previous activity you learned that populations are described in terms of size and density. You also learned that four primary factors control populations and may cause a population to increase or decrease over time. Few populations are perfectly constant, especially over long periods of time.



It is important that you be able to put together the concepts of population size, density, and the factors that cause change. To do this, turn to page 591 in your text which is entitled Case Study: Calculating the Size of a Small Mammal Population. Read through the entire Case Study to get an understanding of what will be expected of you. Then answer the following questions which help you to understand the background of the shrews and how the sampling of the population was done.

1. Do Textbook questions a to f on page 591.

Check your answers by turning to the Appendix, Section 1: Activity 2.

If you wanted to count all of the shrews in the study area it would be a costly and time-consuming task. Would it be worthwhile to search the whole area for every shrew, or is there an easier way? Biologists usually take samples of populations in a number of different areas to get an accurate representation of the entire population. Section 6 of the Case Study presents you with data collected over a ten-year span. Manipulate the data so that it is presented in a more usable form by doing the following questions.

Science Skills

☐ A. Initiating
☐ B. Collecting
☐ C. Organizing
☑ D. Analysing
☐ E. Synthesizing
☐ F. Evaluating

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2. Do Textbook question g on page 591. Round to one decimal place for the average. By finding the total and average numbers you will begin to see a population trend.
3. Do Textbook question 7 on page 592. You may use the total number of shrews trapped each year instead of the average number since the shrew numbers are relatively small. Using the average number would produce a similar curve on your graph.

Check your answers by turning to the Appendix, Section 1: Activity 2.

You have now taken the information that was collected in each quadrant over the ten years and summarized it into an easily understood graph. This is a good representation of a population that has changed over time.

4. To help you analyse this information further, answer Procedure questions h to m on page 592.

Check your answers by turning to the Appendix, Section 1: Activity 2.

The information collected and analysed so far has related to the sample of shrews collected from the various quadrats. You now need to take that information and make estimates as to the number of shrews in the entire study area so that further population analysis can be done.

Science Skills

☐ A. Initiating
☐ B. Collecting
☐ C. Organizing
☑ D. Analysing
☐ E. Synthesizing
☐ F. Evaluating

5. Do Application questions 1 to 6 found on page 592.

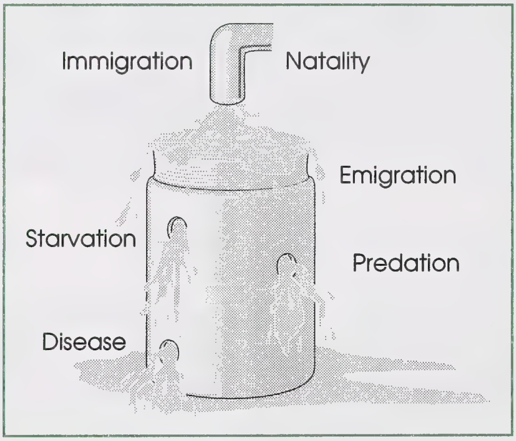
Check your answers by turning to the Appendix, Section 1: Activity 2.

In this activity you have explored the concepts of populations and population growth. The rabbits of Australia grew in numbers because there were no predators or not enough competition from native animals to keep the population in check. The rabbit population grew exponentially causing the density to increase to a point where they began damaging the habitat. Why did nature allow the population to get to such levels? Why don't all populations increase at the rate of rabbits and humans? The next activity will address these issues.

Before you start your explorations in the next activity, turn to page 579 in your text and read the section entitled Chaos Theory and Biological Systems. Simply put, the theory states that predictions regarding any system, including populations, are difficult to make due to the complexity of the system. When you study populations throughout the rest of this section, keep in mind that the predictions made are all subject to variation due to the chaos theory and to the immense complexities in the biosphere. The chaos theory will be further explored in Section 2 of this module.

ACTIVITY

3 How Populations Change



This graphic is a good illustration of how an open population will grow only to a certain point. This is how populations usually behave in nature. They grow until something stops them. In this activity you will examine the factors that prevent the population from growing beyond the capacity of the environment and how different types of populations fit into this concept of changing populations.

Investigation: Population Growth in Brine Shrimp

Objective

The objective of this investigation is to gain an understanding of how populations grow and how food influences growth.

Background Information

Brine shrimp are one of the most widely distributed crustaceans in the world. They are usually found in bodies of water that are strongly saline (salty). The eggs are about 0.2 mm in diameter and they will hatch in 5-6% salt solution. This can be prepared by adding 5 g of salt to 100 mL of water. It is best to hatch them in pond or river water that has had aquarium salt added. Alternatively if pond water is not available, use tap water that has had the chlorine removed by allowing it to sit for a day or two. The shrimp will feed on powdered dried yeast that is ground in a few drops of fresh water and floated on the top of the salt water in which the shrimp live.

Science Skills

☑ A. Initiating
☐ B. Collecting
☐ C. Organizing
☐ D. Analysing
☐ E. Synthesizing
☐ F. Evaluating

1. Devise a problem for this investigation. (Refer to the Objective for assistance.)

2. Formulate a hypothesis for the problem.

Materials

- 60 brine shrimp eggs
- 5% saline solution (prepared as directed in Background Information)*
- two 50 mL test tubes
- powdered dried yeast (available as baker's yeast)*
- magnifying lens
- 10 mL graduated cylinder

* supplied by student

Procedure

- Label one test tube *constant food* and the other *initial food only*.

- Fill the two test tubes 3/4 full of 5% saline solution at room temperature.

- To each test tube add thirty eggs. Count the eggs by placing a small number on a piece of white paper and separating them using a toothpick.

- After 24 h count the number of eggs that have hatched in each test tube. With the aid of the magnifying lens, you should be able to see the shrimp swimming around.

- Count the number of shrimp every 24 h for two weeks.

Science Skills

☐ A. Initiating
☑ B. Collecting
☑ C. Organizing
☐ D. Analysing
☐ E. Synthesizing
☐ F. Evaluating

3. Record your results in an appropriately labelled observation table.

   - After 48 h make two yeast suspensions by placing five granules of yeast into 10 mL of water. Be careful not to add more than five granules of the yeast or you may harm the shrimp. Allow these to sit for a half of an hour.
   - Pour one yeast suspension into each test tube as the initial food source.
   - Every 48 h for the next two weeks, prepare another yeast suspension and add it to the *constant food* test tube. Evaporation should remove water between additions of the yeast suspension so the water will not overfill the test tubes.

Now that you have set up this lab, go back and begin Activity 1. Don't forget to feed and count the brine shrimp while you are busy with the other parts of the module. Complete the analysis and interpretation questions after one to two weeks of data collection have been completed. One week of data collection should give you sufficient data, but two weeks is better. You can keep your brine shrimp living for a longer time if you wish.

Analysis and Interpretation

Science Skills

☐ A. Initiating
☐ B. Collecting
☐ C. Organizing
☑ D. Analysing
☑ E. Synthesizing
☑ F. Evaluating

4. At the end of two weeks, produce a single graph of the growth of two populations using the same set of axis.
5. Why was food added only once to the *initial food only* test tube?
6. Compare and contrast the two populations by analysing the shape of the growth curves.

Check your answers by turning to the Appendix, Section 1: Activity 3.

The previous investigation has allowed you to observe a population growth pattern when food is in short supply and when it is constantly added. There are a number of concepts that were involved in the investigation that need to be further explored.

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Read page 585 of your text to learn about growth curves for open populations and then answer the following questions.

7. Which test tube from the investigation illustrated an S-shaped curve? What factors allowed the stationary phase to last two weeks?
8. What is another term that can be used to describe the stationary phase found in S-shaped population growth curves?

9. Why was a new carrying capacity reached in Figure 25.12 on page 585?

Check your answers by turning to the Appendix, Section 1: Activity 3.

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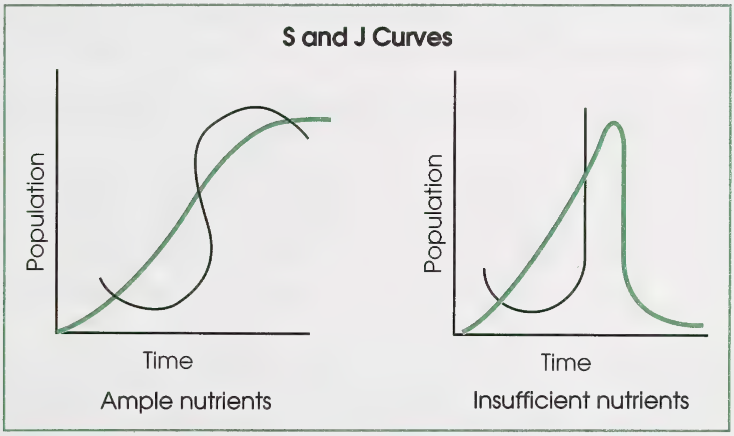
In the investigation, food was the major factor influencing the stability of the brine shrimp population. There are many other factors that limit or promote population growth. Read page 586 on biotic potential and environmental resistance and then answer the following questions.

10. Do Review question 14 from page 589.

11. Using your knowledge of the four factors which regulate biotic potential, state how humans would fit into each factor.

12. What are the major environmental resistance factors that keep the population of brine shrimp in dynamic equilibrium? What factors would not be involved in the investigation?


S and J Curves

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In the investigation, the two graphs did not follow the same pattern. As you have already discovered, the shape of the curve that levels off is an S-shaped curve. To discover information on the curve that rose and then sharply fell, read J-Shaped Population Curve on pages 586 and 587 and then answer the following questions.

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

13. Draw a typical graph of a J-shaped curve.

14. Why did the numbers of the brine shrimp population that were not supplied with food illustrate a J-shaped curve?

15. Predict what factors might affect populations size when numbers increase beyond the carrying capacity.

16. How can the carrying capacity for a population be increased?

Check your answers by turning to the Appendix, Section 1: Activity 3.

Limiting Factors

Factors that affect population growth are not always factors that are in short supply, as in the case of the population size of brine shrimp. In some cases if a population were to have too much of some factor, population decrease could result.

Read pages 588 and 589 on limiting factors in populations and answer the questions that follow.

17. Explain the law of the minimum as it applies to the investigation on brine shrimp.

When studying Figure 25.17 on page 588 it is evident that some abiotic factors can limit the population if they are in short supply and in excessive amounts.

18. List one factor from the brine shrimp investigation that could have been in excess.

19. List two factors from the brine shrimp investigation that were density independent.

20. List two factors from the brine shrimp investigation that were density dependent.

Science Skills

☐ A. Initiating
☐ B. Collecting
☐ C. Organizing
☐ D. Analysing
☐ E. Synthesizing
☑ F. Evaluating

21. Were the brine shrimp more affected by density dependent factors or density independent factors? Explain your answer.

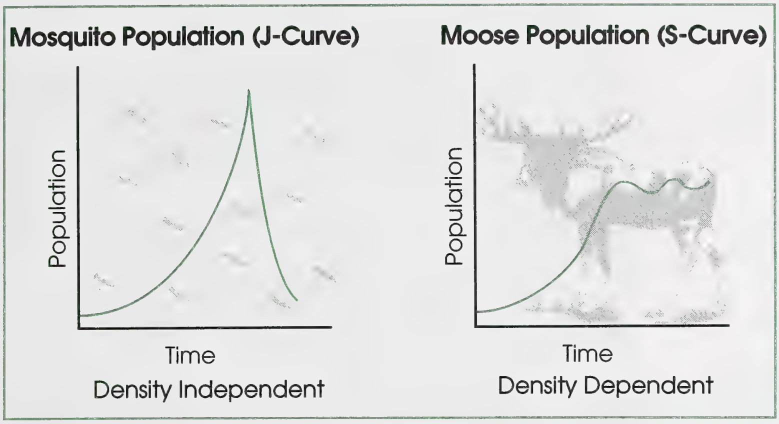
Check your answers by turning to the Appendix, Section 1: Activity 3.

r and K Strategies

Populations that are regulated by density dependent factors are characterized by S-shaped population curves, while populations that are regulated by density independent factors are characterized by J-shaped curves.

As shown in the next illustration, a population of mosquitoes is density independent and will follow a J-shaped curve. It doesn't matter if there are a few mosquitoes or many mosquitoes; the population will increase rapidly and then crash. This occurs mainly because the mosquitoes emerge from their aquatic pupa all at the same time, live only a few days, and die.

Compare this to the moose population in this illustration. This population is density dependent and forms an S-shaped curve. A population of moose will grow until some factor, for example, food, begins to be depleted. This will limit the population to a certain level, a carrying capacity. At this point the population levels off.



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To discover another way the populations can be categorized, read the section entitled r and K Population Strategies on page 589 and then answer the following questions.

22. By analysing the previous graphs, determine which is r-selected and which is K-selected. Give an example of a plant species that follows each selection strategy.

23. Prepare a chart to compare r and K populations using the following comparison categories: environmental conditions, population size, competition, size of individuals, growth of young, reproduction rate, survival during stress, animal species example.

Science Skills

- ☑ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☑ E. Synthesizing
- ☑ F. Evaluating

Check your answers by turning to the Appendix, Section 1: Activity 3.

The jar of water mentioned at the beginning of this activity can be filled to its carrying capacity. The carrying capacity depends primarily on the size of the jar. Like the water level in a jar, a population will become stable at some point where additions are balanced by deletions. In the case of a population of organisms, the balance will be between immigration and natality, which increase numbers, and emigration, predation, starvation, and disease, which decrease numbers. Notice that while a population may appear stable, additions and deletions are always occurring. Food supply, climate, space, and disease are some of the factors that prevent the population from growing beyond a carrying capacity. In the next activity these factors will be analysed with the human perspective in mind.

ACTIVITY

4 Population Structures

COURTESY OF DUCKS UNLIMITED

You own a small pond on which there grows a small amount of duckweed. The quantity of duckweed doubles each day. If the duckweed was allowed to grow unchecked, it would cover the entire surface of the pond in thirty days, choking off and killing all other forms of life. For many days the quantity of duckweed seems like a small problem, so you ignore it. Only when the duckweed covers half of your pond do you perceive a problem and work to stop its growth.

1. On what day will the duckweed cover half of the pond?

Check your answers by turning to the Appendix, Section 1: Activity 4.

In China there has been a stringent policy that each married couple may have only one child. At the same time the Canadian government provides money for each child. Why would one society wish to restrict population growth while another promotes population growth? Perhaps human populations should not be viewed by comparing countries but rather by analysing the global population picture. Read pages 592 to 594 to discover more about human population growth and then answer the following questions.

2. What occurrence is linked to the first significant change in human population growth?

Science Skills

☐ A. Initiating
☐ B. Collecting
☐ C. Organizing
☑ D. Analysing
☐ E. Synthesizing
☐ F. Evaluating

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3. Do Review question 21 found on page 598.

4. By analysing Figure 25.22 on page 594, you can observe a small dip in the human population around 1400 A.D. What catastrophe occurred at this time?

5. As you can see in Figure 25.22, the human growth curve has become very steep over the last 150 years. What is the mathematical description for this type of growth?

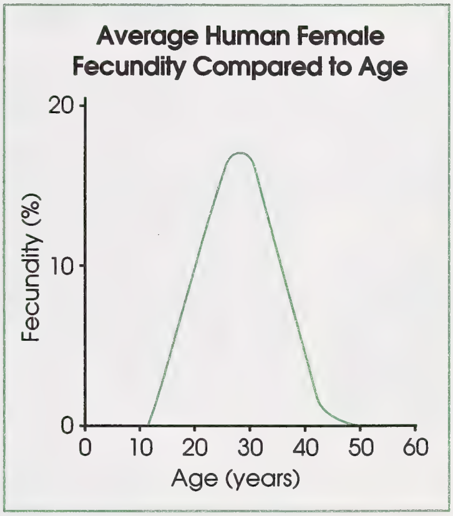
6. Compare the growth curve of humans to the growth curves of other species. Name another species from your studies that has the same growth curve as humans.

7. What growth pattern does the human population appear to be following?

Check your answers by turning to the Appendix, Section 1: Activity 4.

The human global population is growing – of that you can be sure. But are all of the countries on the planet growing at the same rate? Do some countries have stable populations? Are the populations in some countries even declining? The major determinant of whether or not a specific country's population is changing is the **fecundity** of the females. In r-selected species, such as mosquitoes, the fecundity of females is largely due to climatic conditions. However in K-selected species, such as humans, the fecundity of females is relative to the age at which they reach sexual maturity. The following graph illustrates how the fecundity of women changes with age. Analyse the graph; then answer the questions that follow.

fecundity – the condition of being fertile



Science Skills

☐ A. Initiating
☐ B. Collecting
☐ C. Organizing
☑ D. Analysing
☐ E. Synthesizing
☐ F. Evaluating

8. Why does fecundity not begin until around age 12?

9. At what age do females have the highest fecundity?

10. What percentage of babies are born to women at age 30?

11. Why does female fecundity fall to zero around age 48?

Check your answers by turning to the Appendix, Section 1: Activity 4.

You are now aware of the percentage of babies born based upon the age of the female, but what about the average number born per female? During the baby boom years of the late 1950s, the average Canadian female gave birth to 3.9 children. Today this number has fallen to less than 2.0 children.

12. Determine the result to a population's size if the average number of births falls below 2.0 for an extended period of time. Sketch a graph of this population curve.

Science Skills

☐ A. Initiating
☐ B. Collecting
☑ C. Organizing
☐ D. Analysing
☐ E. Synthesizing
☐ F. Evaluating

All of the baby boomers born in the late 1950s are not replacing themselves, which means that the average age in Canada is steadily increasing, while in the long run the population will begin to decrease.

13. What could be possible cause for this decision of the baby boomers to have fewer children?

Population Histograms

The baby boomers are part of the age structure of a population, just as you are a part of a particular age group in the population. The age structure, or **age pyramid**, of a population is another way to organize population data that can be used to determine if the population will grow or decline in years to come. Recall the left column on page 593 where an explanation of age pyramids occurs, and then answer the following questions. Note that if the age pyramids had a vertical line drawn through them, the gender of the population would also be included with males on the left and females on the right. Most human populations are close to 50:50 except where some event such as a war has removed large numbers of males or where infanticide of female babies may have been part of a culture.

age pyramid – a graph used to organize age and gender of a population

Nelson
BIOLOGY

14. Do Review question 20 found on page 598 of your textbook.

15. What factors must be in place for a country to have zero population growth?

16. Into which type of age pyramid would Canada's population fit?

17. What factors would cause the stabilized population for Sweden as found in Figure 25.21?

18. What factors would cause the growing population for Mexico as found in Figure 25.21?

Science Skills

☐ A. Initiating
☐ B. Collecting
☐ C. Organizing
☑ D. Analysing
☐ E. Synthesizing
☐ F. Evaluating

During World War II, millions of males between the ages of 20 and 30 years died.

19. How would this affect the age pyramid of a country that lost a large percentage of its males?

Population histograms are a valuable tool for organizing data. They are able to clearly show how Canada's population is aging while Mexico's population is growing at a rapid rate as the number of young is so high. Each country must be made aware of the problems associated with their unique age pyramid and the problems that the planet faces with an exponentially growing population.

Check your answers by turning to the Appendix, Section 1: Activity 4.

Global Population Concerns

Future population concerns vary for countries with differently shaped age pyramids. The concerns of individual countries are important, but what about analysing the global picture? Each country has boundaries and will establish a carrying capacity within them, but what would happen if there were no boundaries? The global carrying capacity would now be a concern for all.

To discover another viewpoint on the population explosion, read the following excerpts from an article entitled "Red Hot Realities for a Finite Planet," and then answer the following questions.

Population – Red Hot Realities for a Finite Planet

At first glance, it may be hard to see how overpopulation could be your problem – the effects of overpopulation are seldom evident as such. But population is a factor (although not the only one) in every problem associated with urbanization and industrialization – growth. Complicating our understanding further, there are dramatic regional differences in population growth-rates, and in per-capita resource-consumption rates, which means that the population problem is manifested differently in different parts of the world. In the developed world, overpopulation makes itself noticeable by compounding the consequences of excess: pollution, solid-waste disposal, automotive congestion, urban sprawl. In the developing world, the struggle for subsistence – from the land or sea – intensifies with every generation: Increasing numbers of subsistence farmers are driven onto lands that are unsuitable for farming; women are driven further afield in the quest for firewood; and fishery after fishery collapses from contamination and overexploitation. And, according to Zero Population Growth, for the past 25 years the rate of increase in atmospheric CO_2 – the greenhouse gas – has matched the rate of population growth almost exactly. So even in the wilderness you encounter adverse environmental effects, such as acid rain, which have been amplified and multiplied by overpopulation.

How did this runaway phenomenon come about? The basic constraints on the growth of any population of organisms are food supply, disease, and predation. Using our unique tool-

and language-making gifts, we human beings have cleverly (if not wisely) evaded these constraints.

Since the days when there were only a few million of us, there have been quantum changes. Early on, we shifted from a nomadic to an agricultural civilization, increasing our food supplies and our ability to store food. This great change also marked the beginning of serious deforestation and the buildup of salt in irrigated lands. More recently, we tapped into the finite and never-to-be-repeated bonus of fossil fuels, which helped power the industrialization of agriculture and spurred urbanization. Disease control and greater food security decreased infant mortality.

This change in death rates is extremely significant. While human reproductive potential is fairly constant, the question of whether you live to exercise it is not. When the annual birth-rate exceeds the death rate, the population grows. So when family size exceeds two children, population growth follows. Every minute now, 180 people are born and 100 die, for a net gain of about 11,000 souls per hour.

Exponential Growth

Population growth works like compound interest. If a couple has four children (the average number a woman bears today is 3.5), they've replaced themselves twice in one generation. If each of the children follows suit, there will be 16 grandchildren, then 64 great-grandchildren. In four generations, this Adam and Eve have multiplied themselves better than 200 times. (How many showed up at *your* last family reunion?)

Mother Nature doesn't exhibit much tolerance for such growth patterns. In *Population Biology*, Thomas C. Emmel writes: "Exponential growth is abruptly terminated when the carrying capacity of the environment is surpassed and environmental resistance becomes effective more or less suddenly. Such growth curves are characteristic of rapidly reproducing and maturing annual plants, seasonal insect flushes, and man's population growth in recent years, but in general, they are very short-lived phenomena for obvious reasons."

Another impediment to perceiving and acting on overpopulation has been conventional economics, which activist and author Hazel Henderson has called "a form of brain damage." For the most part, economists have been so enraptured by growth, and the magic of markets, that they've been blind to growth's downside. The problem with economics is that it only values the things it can count. Much of what constitutes quality of life can't be measured or counted, and so is omitted from the definition of a successful economic system.

For example, economist Julian Simon, whose work has served as a rationalization for recent U.S. population non-policy, maintains that population growth generates its own solutions. An increased number of humans means not only increased inventiveness, but also additional demand, which will drive a search for substitutes for depleted resources, clean air, and fresh water. Even if this worked, however, the resource for which there is no substitute is biodiversity. Dr. Simon's cheery optimism is bad news for other species.

Carrying Capacity: Recognizing Limits

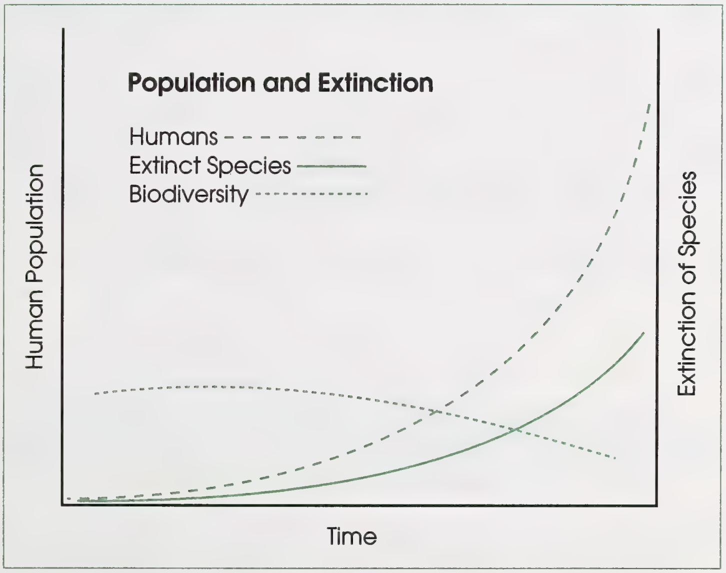
So – suppose we admit there's a complex interplay of social, cultural, and biological factors driving overpopulation. And that – thanks to the intervention of medicine, technology, and trade – the consequences of population growth aren't always obvious. That complexity means that *any* action taken by individuals, communities, nations, and the community of nations will likely offend *someone.* Nonetheless, on a finite planet, maximizing human reproduction clearly comes at great ecological cost, and a considerable cost in human suffering. What would be a positive goal for humanity in all of this?

We need to determine an optimum human carrying-capacity for Spaceship Earth, then limit our numbers to that. Then we must get on with the colossal tasks of sustainable development in the third and fourth world, and sustainable de-development in the first. The number-crunching for this modest project began in earnest nearly 20 years ago.

The aforementioned *Limits to Growth* was the report of a global modelling study that explored Earth's human-carrying capacity. Using systems analysis, computer projections, and a veritable world of data, the authors played out numerous scenarios for the human future, based on different trends in food production, resources, population, industrial output, and pollution. Assuming no change in present patterns, the authors predicted a crash in both population and industrial capacity by the next century. That was the bad news. The good news was that the Earth could sustain indefinitely a population of 6 billion at a European standard of comfort. We're due to hit that 6 billion mark in four years, however.

Besides the sheer number of us, our environmental impact has also to do with the choices that we, industry, and government make about resource consumption and waste disposal; about land use and transportation; about energy generation and conservation. Decisions about all those things can magnify or modify the impact of the increased human numbers.

Ecologists Paul and Anne Ehrlich, in their recent book, *The Population Explosion*, suggest the following equation for thinking about some of these interactions: Impact equals Population X Affluence X Technology, or I = PAT. Understood that way, there's no single culprit. I = PAT helps explain why population is not just a problem of the developing countries. Although countries like the U.S. and Japan have relatively low populations, this is counteracted by the abundance of affluence and technology. According to the Ehrlich equation, the environmental impact of a baby born in the U.S. will be 35 times that of an Indian baby, and 280 times that of a Haitian child. Therefore it makes both practical and moral sense for people on the affluent side of the equation to reduce their impacts on the environment by reducing waste and, ultimately, consumption, as well as by reducing family size.[1]



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[1] Reprinted with permission from the May-June 1991 issue, pp. 46-51 of *GARBAGE Magazine*. Two Main Street, Gloucester, MA 01930.

20. Identify the problems of overpopulation in the developed world.

21. Describe the problem of overpopulation in the developing world.

22. Summarize how humans have been able to overcome the basic constraints of population growth.

23. According to the article, what have been the negative effects of overcoming the constraints to population growth?

24. Identify what "Mother Nature doesn't exhibit much tolerance for," and describe what Thomas C. Emmel feels is bound to happen as a result.

25. State how economist Julian Simon rationalizes human population growth.

Science Skills

☐ A. Initiating
☐ B. Collecting
☐ C. Organizing
☑ D. Analysing
☑ E. Synthesizing
☑ F. Evaluating

26. Analyse the graph in the article and evaluate how it relates to the statement "...the resource for which there is no substitute is biodiversity."

27. What was the good and bad news that the authors predicted about the human population problem?

28. Explain the equation that was developed to help describe the problem of human population growth.

Wise use of technology could provide a means to reduce the human impact on the Earth.

29. Compare the effect on human impact (I) of increasing technology (T) in these two equations. Use simple numbers to illustrate your comparison.

Equation A	**Equation B**
$I = PAT$	$I = \frac{PA}{T}$

Check your answers by turning to the Appendix, Section 1: Activity 4.

The human population dilemma is something to be taken seriously. Throughout the activity, thoughtful questions were asked forcing you to contemplate the growth rate of humans on this planet. These same challenging questions and methods of analysis directly relate to the natural populations you have studied. Ultimately, human actions determine the future for all species and that responsibility must be taken seriously to avoid paths to extinction of human and non-human species.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

In this section you have discovered how populations are affected by limiting factors and how populations can be graphically represented.

To help you understand these concepts, view the video *Aspects of Ecology: Populations.* The video will also help you review some of the concepts covered in Module 6. Watch the video, and answer the following questions by filling in the blanks.

1. The group of organisms that interbreeds to produce fertile offspring is called a ______________.
2. All living things live together in ______________.
3. ______________ ______________ study factors that affect winter survival, predation, and availability of nutrients.
4. The two main forms of population distribution are ______________ and ______________.
5. Resource conservation and management has the ultimate goal of maintaining a ______________ population.
6. The most important aspect of population distribution is calculating a population's ______________.
7. The population of bison at Elk Island National Park is a ______________ population because of the two-metre-high fence that surrounds the park.
8. The four factors that limit the carrying capacity of bison at Elk Island National Park are ______________, ______________, ______________, and ______________.
9. The growth curve for bison that results from population management practices in Elk Island National Park is an ______________ curve.
10. When overcrowding occurs in a closed system, natality ______________ and mortality ______________.
11. The type of growth curve for bison that would be evident if population management was not done in Elk Island National Park is a ______________ curve.

Stop the video and check your answers; then return to watch the second half of the video.

Check your answers by turning to the Appendix, Section 1: Extra Help.

12. The four ways that a population may change its numbers are ______________, ______________, ______________, and ______________.

13. The two factors that caused the population of Richardson ground squirrels to decrease were ______________ and ______________.

14. The ______________ ______________ of Calgary in the late 1970s was quickly reached due to immigration based on a prosperous economy.

15. Dr. Stephen Herrero feels that the benefit of reintroducing endangered species into the wild is that it gives people ______________ and the knowledge that they are not always ______________ the environment.

16. The focus of Ellen McDonald's research on the Athabasca sand dunes is how ______________ factors affect the growth of plants.

17. ______________, ______________, and ______________ are limiting factors that may cause humans to reach their carrying capacity.

Check your answers by turning to the Appendix, Section 1: Extra Help.

Enrichment

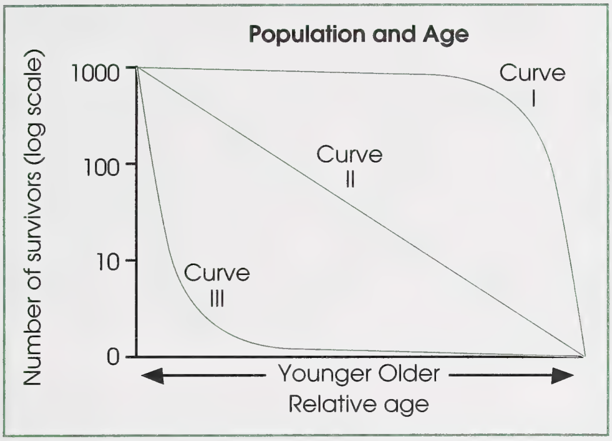
Do one or more of the following.

1. Dr. David Suzuki has brought to the public's attention the information that many economists work with principles based on the assumption of unsustained growth. As a biologist, Dr. Suzuki states that this type of growth cannot continue as growth always has limits put on it by the environment. He contends that population and economic growth will be limited by the environment. Using your knowledge of population biology, write a paragraph defending this position.

2. a. Design an experiment that would determine the effect of population density on the reproductive rate of voles.

   b. Identify two fixed variables that you would control to ensure the validity of the experiment. Explain why each of these would have to be controlled in order to get reliable results.

3. Examine the graph and then answer the questions that follow.



a. Describe what each curve represents in terms of survivorship of individuals. Discuss differences in age, mortality, and life span.

b. Which curve represents human populations?

Check your answers by turning to the Appendix, Section 1: Enrichment.

Conclusion

In Section 2 you studied limiting factors and learned how environmental resistance affects population size. You also learned how to analyse population data and apply it to real situations. With the information from this section, the pattern of human population growth should seem clearer.

The human population in some areas on Earth has periodically reflected a J-shaped curve. In Europe, bubonic plague or the Black Death caused a rapidly increasing population to suddenly crash. Millions died in just a few years. In Africa in the mid-1900s, civil war killed several million people. Villages were left empty. The population was gone. Over a short time this would seem to illustrate a J-shaped curve. But biologically the human population on a global basis should follow an S-shaped curve. Long life span and low reproductive rate together with science and technology should stabilize the human population at some global carrying capacity. So far this seems not to have occurred. The future of human exponential population growth remains uncertain but there is no good reason why the human population would not follow a predictable pattern.

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Section 1 Assignment: Populations

Review the Evaluation information found in the introductory pages of this module.

Response Page Setup

It is important to number and clearly identify each page with the following information at the top:

Biology 30 – Module 7 | Section 1 Assignment | Page # | Name and ID#

Be sure to write legibly. Leave a wide left margin and number all of your pages.

Carefully read each of the following multiple choice questions and decide which of the choices **best** completes the statement or answers the question. Each question is worth 1 mark.

Use the following information to answer the next six questions.

A family counted the population of Richardson ground squirrels (gophers) in their pasture of 250 ha over a ten-year period from 1980 to 1989. The results of their count are shown in the following chart.

Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Population	14	42	73	115	132	115	80	112	106	110

1. Calculate the density per hectare of the gopher population in 1986.

   A. 0.32 gophers/ha
   B. 20 gophers/ha
   C. 3.125 gophers/ha
   D. 80 gophers/ha

2. Calculate the rate of change in density of the gopher population from 1980 to 1984.

   A. 0.03 g/ha/y
   B. 22.5 g/ha/y
   C. 0.12 g/ha/y
   D. 26.4 g/ha/y

Science Skills

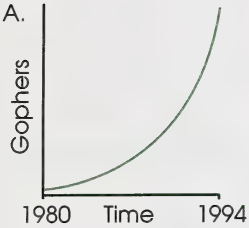
☐ A. Initiating
☐ B. Collecting
☐ C. Organizing
☑ D. Analysing
☐ E. Synthesizing
☐ F. Evaluating

Reproduce the science skills assessment box after your response to this question. Remember to indicate your evaluation of your skill level for each identified science skill. Be sure to include the spaces for teacher assessment.

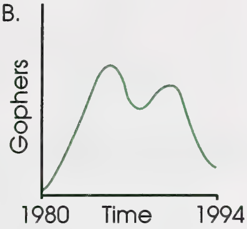
Self:	A. ☐	B. ☐	C. ☐	D. ☐	E. ☐	F. ☐
Teacher:	A. ☐	B. ☐	C. ☐	D. ☐	E. ☐	F. ☐

3. Which of the following growth curves best illustrates the population of gophers from 1980 through to a projected 1994 population, considering that all environmental conditions in the pasture remain the same from 1980 to 1994?

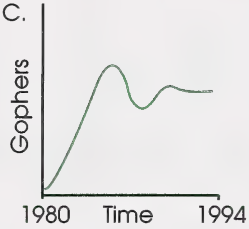
A.



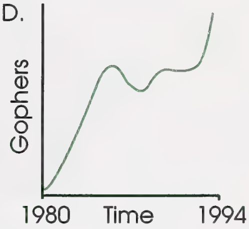
B.



C.



D.



4. During what year did a predator species discover the gopher population in the pasture?

   A. 1980
   B. 1985
   C. 1990
   D. 1994

5. Estimate the carrying capacity of the pasture.

   A. 50
   B. 80
   C. 115
   D. 132

6. During which period did exponential growth occur?

   A. 1980–1982
   B. 1980–1984
   C. 1984–1987
   D. 1985–1989

7. A uniform distribution pattern for a population may indicate that

   A. the population is spreading out and increasing its range
   B. the density of the population is low
   C. individuals of the population are intensely competing
   D. attraction or repulsion between individuals is absent

8. The carrying capacity for a population is

   A. the number of individuals in a population
   B. set at 8 billion for the human population
   C. reached when mortality exceeds natality and emigration exceeds immigration
   D. the number of a species that can be supported by the habitat

9. Five countries differ only in their age structure. The population that will grow the most in the next ten years is the one with the greatest fraction of people in age group

   A. 1-10
   B. 10-20
   C. 20-30
   D. 30-40

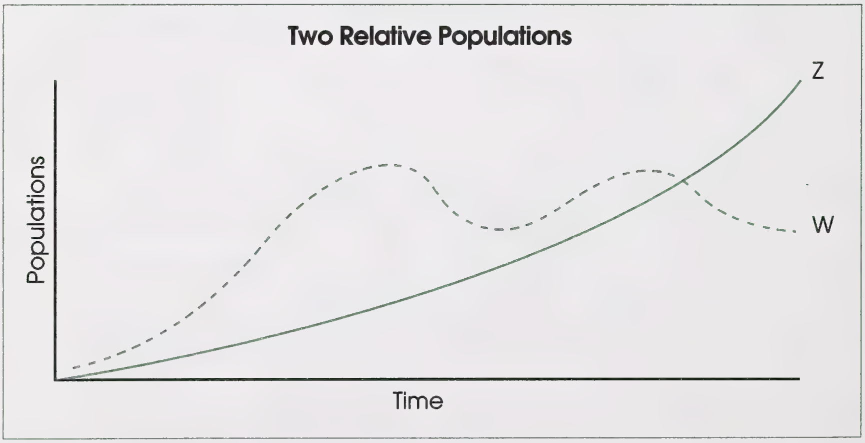
10. Which of the following terms is not characteristic of human populations in developed countries?

    A. low fecundity
    B. r-selected
    C. S-shaped growth curve
    D. clumped distribution

11. In making beer, yeast is kept in an environment without oxygen. The yeast uses sugar as a nutrient and produces carbon dioxide and alcohol as waste products. Why would the yeast population most likely decline after a period of time?

    A. increased temperature
    B. increase in frequency of mutations
    C. lack of oxygen
    D. decreased nutrient supply

12. Which statement is incorrect regarding the two population growth curves?



    A. Curve Z is a complete J-shaped curve.
    B. Environmental conditions caused Population W to stop exponential growth.
    C. Population W is likely K-selected.
    D. Both types are possible in natural populations.

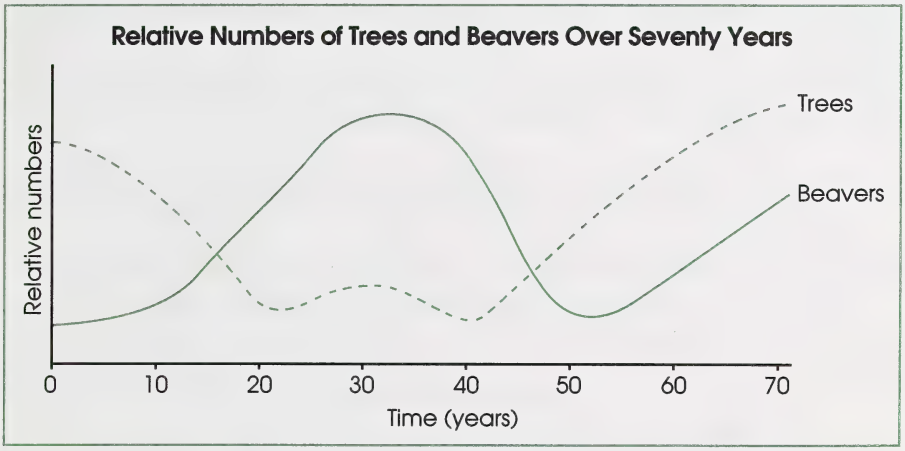
13. Assume that a population measures 1000 individuals at the present time. Mortality is 130/year, natality is 200/year, immigration is 50/year, and emigration is 80/year. What will the population be two years from now?

    A. 1040
    B. 1080
    C. 1140
    D. 1500

14. Why has the human population grown so much in the last 150 years?

    A. increased immigration
    B. population controls
    C. decreased mortality
    D. increased natality

The next two questions are based on a long-term study of a beaver population and the density of trees on which beaver feed.



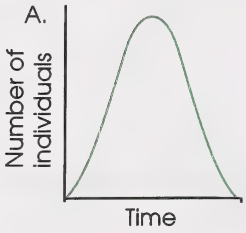
15. An external parasite which lives only on beavers would have the largest population size during which year?

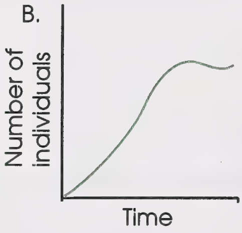
    A. 10
    B. 20
    C. 30
    D. 40

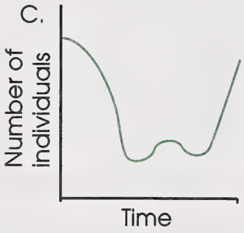
16. The beaver population probably declined between year 30 and 40 because of

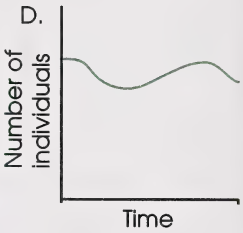
    A. abiotic factors
    B. competition with other species
    C. parasitism
    D. scarcity of food

For questions 17 to 19 select the following graph which best represents the growth of the population described.









17. Eight *Drosophila* (fruit flies), four of each gender, were placed in a bottle with a nutrient medium and the bottle was sealed. The bottle was incubated for a number of months with counts of the population being made periodically until no flies remained.

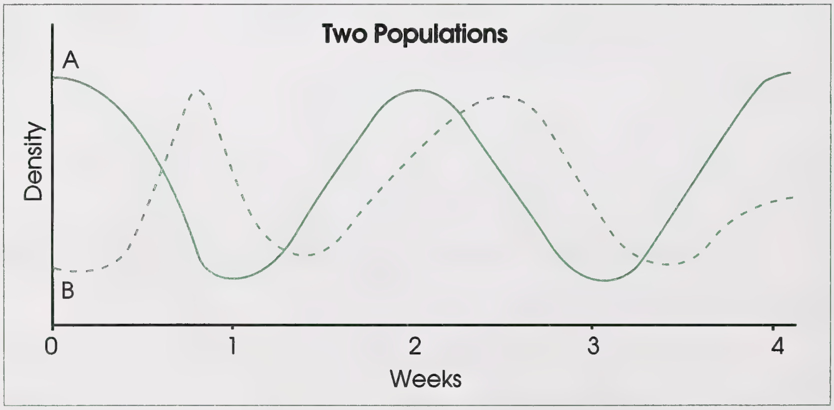
18. An area that was infested with mosquitos was sprayed for a few years with DDT. When it was discovered that the insecticide produced undesirable effects in other populations, the spraying was stopped.

19. A species of lizard was introduced onto a small oceanic island, established itself, and came into dynamic equilibrium.

20. Place the terms in the correct order for the growth of a population of paramecium in a sealed test tube with a finite supply of nutrient provided. **(1 mark)**

    a. stationary phase b. lag phase c. death phase d. growth phase

In an experiment, a student added a small number of algae to a fish tank containing nutrients and exposed to light. *Daphnia* that feed on the algae were also added to the fish tank. The student was interested in the population change and interaction of the species. The population change was observed for four weeks and the results were graphed as a population density curve as shown.



21. a. Which curve on the graph represents the population of algae? **(1 mark)**

The student decided to add more *Daphnia* to the fish tank after the four-week observation period to determine if any changes would result.

b. Explain how the density of algae might change the next day. **(2 marks)**

c. Hypothesize how the density of *Daphnia* might change by the following week. **(2 marks)**

d. If another species that also fed on algae was introduced to the fish tank, conclude how the population of *Daphnia* and algae would respond? **(3 marks)**

22. Mice living in a warehouse of 100 m^2 were studied by an ecologist. The following chart indicates how the fecundity of the mice was affected by the density of the mice. Mice in this warehouse will have six litters per year.

Year	1991	1992	1993	1994
Density mice/m^2	3	6	9	10
Average number of young per litter	6.2	6.2	5.0	4.8

a. Determine if the population of mice is r-selected or K-selected and provide supporting evidence from the data. **(3 marks)**

b. Explain what limiting factors might lead to this decrease in fecundity when the population density rises. **(3 marks)**

c. Draw a graph of the mouse population size (not density) from 1991 to what you would hypothesize to occur in 1996. **(4 marks)**

23. In a paragraph, interpret the meaning of the following statement. "Actual population size represents a compromise between biotic potential and environmental resistance." **(4 marks for correct interpretation and 2 marks for communication)**

24. Mange is a condition caused by mites burrowing into the skin causing severe itching. It mainly affects coyotes in the wild and is spread only through direct contact between individuals. It can be passed on to dogs and even humans. The coyote will scratch itself so much that the fur will eventually fall off. If this occurs in the winter, the animal may develop hypothermia and die. Discuss the occurrence of mange in coyotes as density-dependent or independent. **(3 marks)**

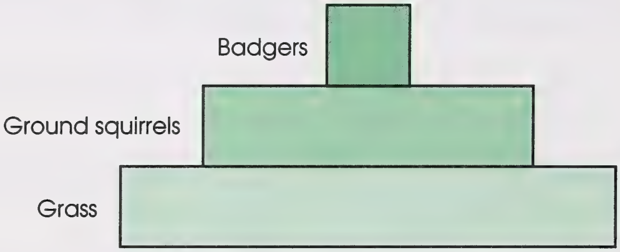
25. a. Use the following data on white-tailed deer to draw a population pyramid. Refer to the population pyramids on page 593 in your text if necessary. Fecundity of females begins at age 2 when a normal litter size is two. **(3 marks)**

Age	Males	Females
1	72	75
2	35	33
3	6	15
4	12	15
5	14	11
6	8	9
7	7	6

b. Interpret the population pyramid. **(3 marks)**

c. Hypothesize what may have occurred to the animals at age 3 and predict what will happen to the population size as a result? **(2 marks)**

26. Badgers, ground squirrels, and grasses may form a food pyramid as shown. Numbers are arbitrary. Their populations are interdependent.



a. Discuss how an increase in the ground squirrel population will affect both the badger population and the grass population. **(2 marks)**

b. Describe the relationship between changes in the badger population and changes in the grass population. Illustrate both positive and negative affects on grass by badgers. **(3 marks)**

SECTION 2 Succession

COURTESY OF DUCKS UNLIMITED

Imagine going on a mountain hike. You begin by walking through a mixed forest. As you climb higher, the trees change to spruce, then pine, and then finally open alpine meadow. Above the meadow, bare rock reaches to peaks with patches of snow glistening in the sunshine. These changes in vegetation represent responses by populations and communities to environmental conditions.

In this section you will explore the factors that control these changes and study how humans interfere with natural change. As you progress through these active communities, keep in mind that they represent gene pools struggling to process matter and energy in the biosphere.

This section concludes with activities that help you prepare for your final exams.

ACTIVITY 1

Understanding Succession

Have you ever looked at an old photograph of a familiar area and thought "It doesn't look anything like that now"? In only a few years trees grow, vegetation changes, and populations increase or decrease. Things never seem to stay the same for very long. This must be natural. If it is, what controls the direction these changes take? Could all organisms be programmed for change?

Biologists recognize a process called succession that seems to answer these questions.

Nelson BIOLOGY

To begin your studies in succession, read text pages 600 to 603 and then answer the questions on page 603.

1. Do Review questions 27 to 31.
2. How does disturbing a site affect the progression of successional stages?

Check your answers by turning to the Appendix, Section 2: Activity 1.

In Module 6 you learned about the importance of survival and studied various symbiotic relationships that illustrated different species living closely together. Relating these ideas to succession will increase your understanding of this natural process.

3. Which relationship best describes what happens during successional changes?

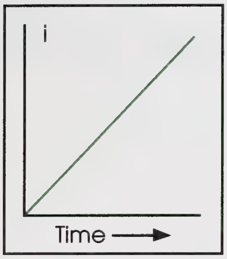
4. What may be the result of stress placed upon the individuals in a population of organisms by competition?

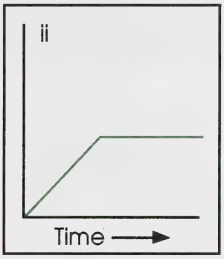
Check your answers by turning to the Appendix, Section 2: Activity 1.

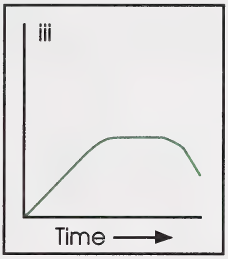
Nelson
BIOLOGY

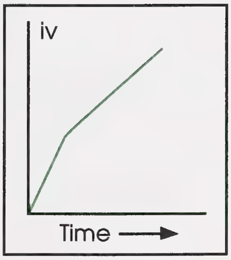
On pages 602 and 603 of your text, four generalizations about succession are identified. The following graphs express these generalizations in a different manner.

5. Which graph matches each of the following statements? The vertical axis is not labelled on each graph. You have to identify the responding variable.









Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☑ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

______ a. Diversity changes most rapidly during the early stages of succession.

______ b. The total number of species dramatically increases during early succession, levels off, and then eventually declines.

______ c. Food webs become more complex as succession proceeds.

______ d. The total biomass and nonliving organic matter increase during succession and levels off in the climax community.

You should now have a working understanding of the role that succession plays in shaping the environment. When you look at an ecosystem, remember its present appearance is just that. How it looked in the past and how it will look in the future will probably be different. Next, you will apply what you already have learned about succession.

Primary Succession

Can you imagine a layer of ice half a kilometre thick stretching from Alaska to the central United States? What would it be like where you are sitting right now? Glaciers have covered large parts of North America as many as four times in the geologic past. The last glaciers that covered Alberta began to recede about 11 000 years ago. Remnants of these mountains of ice can be found high in the Rocky Mountains. Alberta is one of the few places in the world where you can drive right up to a glacier and observe it. It is believed that nothing lives under a glacier. All plants and animals are destroyed. Soil is scraped away to bare rock.

As a glacier recedes, the newly exposed substrate begins to undergo succession. Read the Case Study on pages 604 and 605 of your text; it will provide you with an opportunity to analyse a successional pattern.

Follow the outlined procedure and then answer the questions in the Case Study.

6. Do Procedure questions a to e.

7. Compare diagram (iii) to diagram (vii). Which stage provides the greatest biomass?

Check your answers by turning to the Appendix, Section 2: Activity 1.

In as little as 80 years, a mature forest has grown from bare soil. Beginning with mountain avens and ending with mighty spruce trees, the process of succession has created a unique ecosystem.

8. Answer Application questions 1 and 3 from the Case Study on page 605 in your text.

9. Is this Case Study an example of primary or secondary succession? Support your answer.

Check your answers by turning to the Appendix, Section 2: Activity 1.

If you ever have the opportunity to visit the Columbia Icefields, be sure to look for these different communities which show succession in action.

Secondary Succession

Succession also takes place in ecosystems that have already been established. This is called secondary succession. The following questions deal with the successional changes in a field abandoned in central Alberta. Small pockets of aspen surround the field. At one end of the field towers a large spruce. No human interference has occurred since the field was last tilled in 1986.

10. Using the knowledge that you have gained about succession, predict the pattern of succession likely to occur in this field since it was abandoned.

11. Predict the appearance of this site 50 years from now.

What you have done is apply the standard pattern of secondary succession.

Chaos Theory

The predictions that you were able to make in your study of succession were based on general observations collected over a long period of time. Modern ecology makes extensive use of mathematical and computer models to analyse ecosystems and the changes occurring in them. These sophisticated techniques allow for much more specific predictions. However, in order to make these predictions, all data affecting a site must be collected, numerated, and then entered into the mathematical model. A new branch in the science of mathematics is shedding more illumination on prediction making. Chaos theory is a method of examining what appears to be random patterns to determine if indeed orderly events are occurring. The complexity of biological systems may mask patterns of change within the system. To gain more information on the chaos theory and how it is applied to biological systems, read pages 579 and 580 of your text. Then answer the questions that follow to apply the chaos theory to the concept of succession.

haos theory –
mathematical
nethod of trying
o find order in
pparently
andom events

12. The chaos theory attempts to account for what type of events?

13. Why are biological systems excellent prospects for the application of chaos theory?

The chaos theory proposes that the apparently ordered pattern of succession is affected by random events such as a forest fire. Over a short time period, for example 20 years, forest fire may seem a random event. But over a longer period, such as 100 or 200 years, even fire may occur in a pattern.

14. How would your answer to question 10 have changed if a fire had occurred in the previously discussed field 20 or 40 years after being abandoned?

Check your answers by turning to the Appendix, Section 2: Activity 1.

The pattern of succession does not ultimately lead to a climax community. Regular disturbances such as fire or floods and human activities often prevent the climax community from ever appearing. In the next activity you will investigate the role fire plays in succession.

ACTIVITY

2 Fire: A New Look

A forest fire rages through a beautiful alpine valley. Hours afterwards all that remains is charred earth and smouldering stumps. A cool refuge that has existed for hundreds o years has been turned into an apparently lifeless landscape. But life is there. Soon new growth sprouts from the charred earth nourished by the minerals left behind in the ash and warmed by the spring sun on the blackened earth. In a miracle that has been replayed since the beginning of time, nature heals its ugly wounds.

Fire. The thought of a major conflagration brings fear to many. This destructive power has been thought of as something that must be prevented at all costs. In the last 30 years, a modern view has developed that recognizes the important ecological role that fire plays in the succession or maintenance of ecosystems. Fire is now used as a management tool to improve grazing for herds of mountain sheep and elk by eliminating alders and willows that encroach on meadows.

Fire can be a powerful tool in shaping the environment. As you will learn, some species are adapted to benefit from fire.

In Alberta, three particular species of trees depend on fire to regenerate. Aspens will sprout from surface roots if the mature trees are stressed or killed. Jack pines and lodgepole pines depend on fire to release seeds from the cones of mature trees. These cones are one of the hardest materials made by living organisms. When pines burn, the brief but intense heat produced melts the resin that has sealed the cones for decades. Shortly after the cones open, the seeds are released to a newly prepared bed of ash-rich soil.

1. How could these pine trees be at an advantage in reestablishing after a fire?
2. When you observe a stand of pines, would you expect the trees to be of the same age class or would the trees all vary in ages?

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Check your answers by turning to the Appendix, Section 2: Activity 2.

The following case study will allow you to explore succession, taking into account the special nature of these fire-adapted species. Read the Background Information and then answer the questions as indicated.

Case Study: Fire Succession in a Boreal Forest

Objective

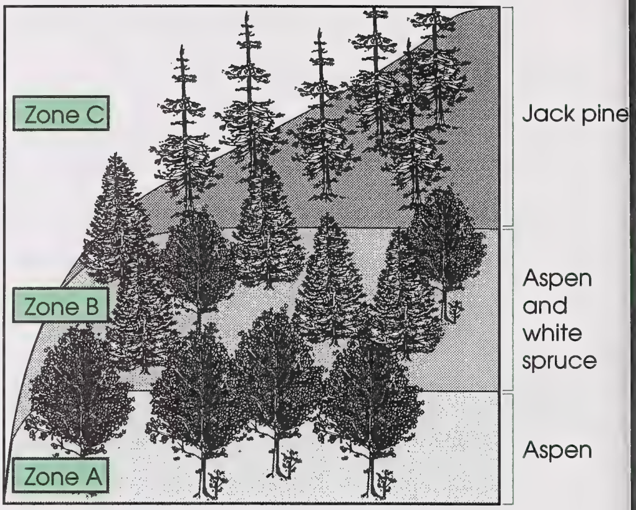
The objective is to investigate forest regeneration following a major burn.

Background Information

A forest fire has swept through a section of the boreal forest. As a result of a prior vegetation analysis, the forest structure of one site was well known. The base of the slope consisted mainly of aspen poplar. The slope was a mixture of poplar and white spruce and the occasional jack pine. The top of the slope consisted of fairly dense jack pine trees.

Fire damage was quite extensive but not sufficient to totally kill all the tree root systems.

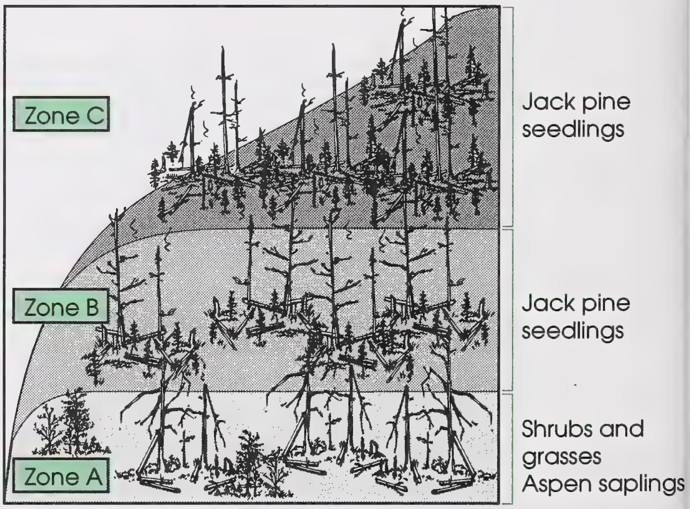
A group of biologists took advantage of the original vegetation analysis to establish a long-term study on forest succession in the area. Although many plant species are involved in boreal forest succession, only index (most common) species will be discussed. The following years mentioned are those years after the fire. Use any appropriate reference materials to help you answer the questions presented in this case study.



Original (prior to fire)

Year 1

A few burnt trees remained standing but are dead at least to the roots. The ground was extensively covered by fireweed, a perennial herbaceous plant, along with a variety of other herbaceous plants and grasses. In Zone A, new saplings of aspen were visibly growing from the bases and roots of the burnt aspen poplars. Jack pine seedlings are evident in all zones from fire-adapted seeds.



Year 1

Science Skills

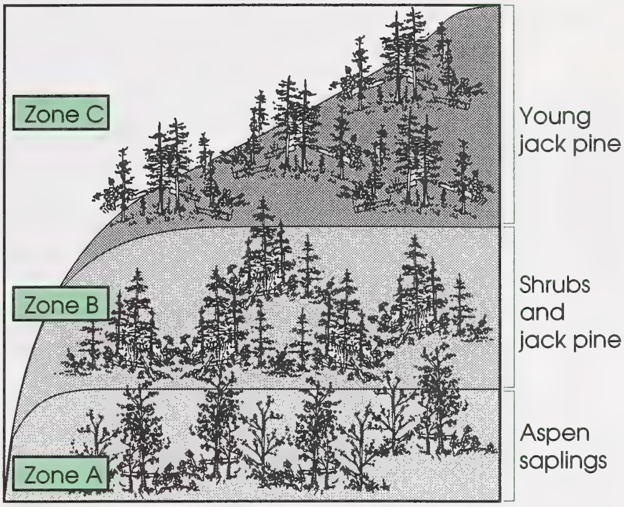
☐ A. Initiating
☐ B. Collecting
☐ C. Organizing
☑ D. Analysing
☐ E. Synthesizing
☑ F. Evaluating

3. Which of the two types of succession would normally follow a forest fire? Explain.
4. Is there any evidence that a forest might regenerate? Explain.
5. Why did the described vegetation rather than the original tree species develop in the area?

Year 5

Zone A is well covered with aspen poplar tree saplings. Intermixed are a variety of perennial herbaceous plants (eg., wild rose) and some shrubs. The ground is covered by low plants (strawberries, some mosses, and twin flower).

Zones B and C, the drier part of the study site, are dominated by one- to two-metre tall jack pine saplings. A similar type of undergrowth to Zone A has developed but some of the herbaceous and ground cover species differ.



Year 5

Science Skills

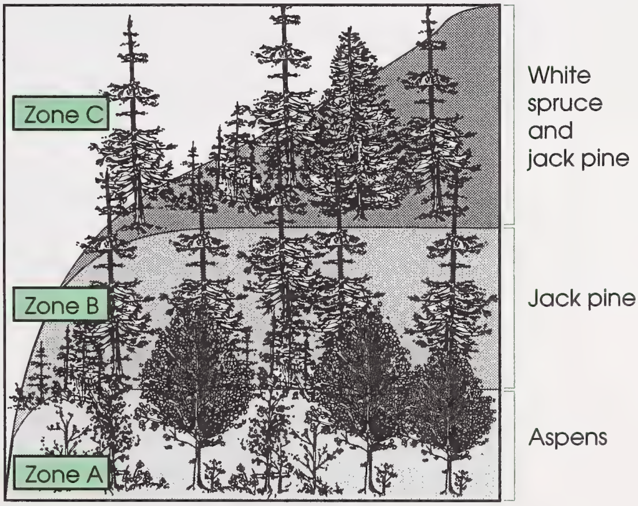
- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☐ D. Analysing
- ☑ E. Synthesizing
- ☑ F. Evaluating

6. The poplars have dominated Zone A. Why?
7. What trees dominated Zones B and C before the fire?
8. Explain why jack pine is now the major tree species.
9. Why might there be a difference between the herbaceous and ground cover plants in Zones A and C?

Year 20

Zone A is dominated by aspen poplar trees whose canopy of leaves forms a dense cover. The number of herbaceous and ground cover plants is reduced from earlier years. A few shrubs such as dogwood are present. Some aspen poplar saplings can be observed.

Zone B is dominated by well-developed jack pines. A few shrubs are present and the ground cover is a mixture of herbaceous plants and low-level woody plants such as bearberry. The tops of the trees are separated. Some soil is exposed. Some small jack pine saplings are randomly distributed in the zone.



Year 20

Zone C is similar to Zone B. However, under the canopy of the jack pine trees a large number of white spruce saplings and seedlings are easily observed. The odd jack pine sapling is also found here.

Science Skills

☐ A. Initiating
☐ B. Collecting
☐ C. Organizing
☑ D. Analysing
☐ E. Synthesizing
☑ F. Evaluating

10. Why is Zone A so different from Zones B and C?

11. Explain the presence of white spruce in Zone C.

12. Is there any evidence of forest succession in each of the zones?

13. Predict the overall appearance of the study site as observed fifty years after the fire. Concentrate on the tree species only. Use any appropriate scientific terms related to forest succession.

Science Skills

☐ A. Initiating
☐ B. Collecting
☐ C. Organizing
☑ D. Analysing
☐ E. Synthesizing
☑ F. Evaluating

14. Why was there a rapid growth of a variety of plant species in the first few years after the fire?

15. What would happen to the animal life in the study site over the years? Explain.

16. At what time over the fifty years would you expect to find the greatest variety of animal life? Explain.

Check your answers by turning to the Appendix, Section 2: Activity 2.

The changes that occur after a fire begin very quickly and then proceed more slowly as the dominant vegetation regrows. This example of secondary succession illustrates the changes that occur after a fire.

PHOTO SEARCH LTD.

17. Why might you expect the pattern of succession to be different after a region has been logged rather than burned?

18. After an area is logged, it is often replanted with the climax species that was removed.

    a. Using the concept of secondary succession, explain why the planted seedlings may not thrive.

b. If the area was left to regenerate naturally, explain why a mature climax forest will not appear as soon.

Check your answers by turning to the Appendix, Section 2: Activity 2.

Now you are going to investigate the conditions required to open lodgepole pine or jack pine cones.

Investigation: Effect of Heat on Pine Cones

Objective

The objective of this investigation is to examine the conditions required to open sealed pine cones.

Materials

- pine cones
- heat source such as a stove*
- timer*
- large forceps or tongs*
- metal tray*

*supplied by student

Procedure

- Preheat an oven to 180°C.
- Place a cone in the oven for 2 min to break resin bonds.
- Remove cones from oven and keep in a warm place for 3 or 4 days until scales are fully opened.
- Tap the cone gently to release the seeds.
- Sketch a diagram of the seeds.

The next set of questions are designed to guide you through to a conclusion.

Analysis and Application

Science Skills

☐ A. Initiating
☐ B. Collecting
☑ C. Organizing
☑ D. Analysing
☑ E. Synthesizing
☐ F. Evaluating

19. Why would you expect some variation in the amount of heat required to open the cones?

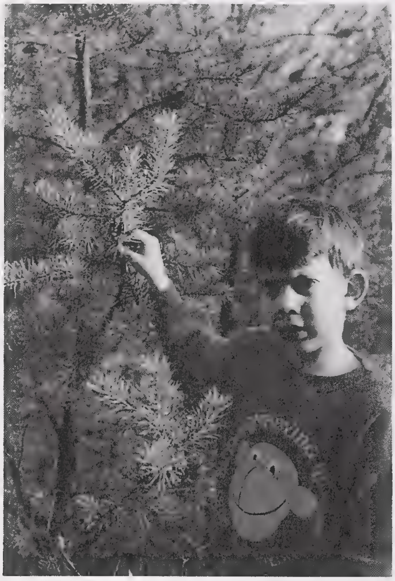
20. What would happen if the cones got too hot?

21. Observe the seeds closely. Why are they winged?

22. Suggest some possible uses that could be made from the material that seals these cones.

Check your answers by turning to the Appendix, Section 2: Activity 2.

An optional extension of this investigation would be to collect the released seeds and plant them. To accomplish this, rub them in your hands to remove the wings. Plant them 5 mm deep into moist soil. Germination should take place within two weeks. The seedlings can be planted outside, in the spring, after danger of frost has passed.



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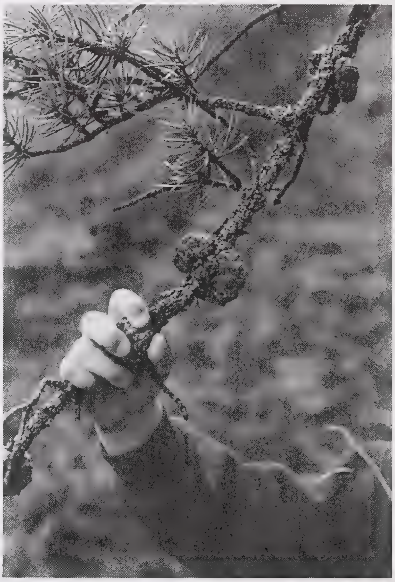


TERRY SLIWKANICH

The preceding photographs show cones of a young and mature pine.

23. Can you notice a difference? Explain.

It is interesting to note that young trees do not form serrotonous (sealed) cones and their cones open up as do other conifers.

24. Provide a reason as to why the young trees do not form serrotonous cones.

Check your answers by turning to the Appendix, Section 2: Activity 2.

ACTIVITY

3 Investigating Succession

Forested regions often have grassland areas within them and vice versa. Opposite sides of a valley may have different vegetation types. How is this possible? In this activity you will examine two different communities in close proximity and analyse how abiotic factors contribute to a microclimate. Microclimates are conditions within a small region that can be significantly different; this allows different plants to grow and form a different community.

PATHWAYS

If you have access to the materials, do Part A.
If you do not have access to the materials, do Part B.

Part A

Investigation: Microclimates and Succession

Objective

The purpose of this investigation is to compare two different microclimates in close proximity and examine their patterns of succession.

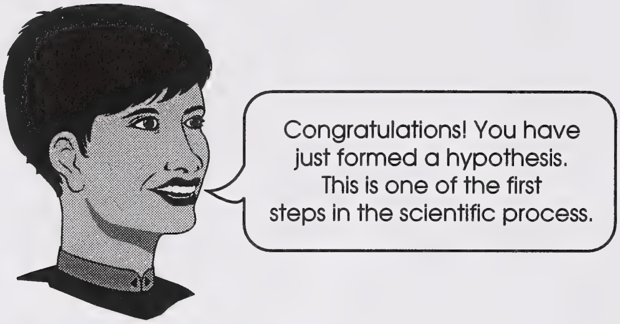
Background Information

To get started, answer the following questions that review some of the principles that affect terrestrial ecosystems such as you studied in Biology 20. Examine the two sides of the coulee or ravine in the previous photograph.

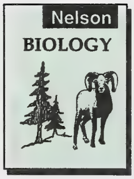
Science Skills

☐ A. Initiating
☑ B. Collecting
☑ C. Organizing
☑ D. Analysing
☐ E. Synthesizing
☐ F. Evaluating

1. What differences do you see in the two slopes?
2. If the two sites are only a few hundred metres apart, is it reasonable to assume that both sides receive the same amount of precipitation?
3. Predict which ecosystem requires more moisture.
4. Propose a reason as to why the south bank has more moisture.


Congratulations! You have just formed a hypothesis. This is one of the first steps in the scientific process.

In the remainder of this activity you will be able to examine these microclimates in order to provide evidence that supports or falsifies your hypothesis. If the amount of available moisture is the critical abiotic factor, you will be assessing how a variety of other factors affect the amount of moisture present.



To start your research, go to page 601 of your text and read the information on microclimate.

5. For each of the following factors, determine whether it will increase the amount of moisture in a situation or reduce it. Make a table that summarizes the effects these factors have in relation to moisture. The factors are attitude (direction), slope, air temperature, soil temperature, light intensity, wind speed, relative humidity, percolation rate (how fast the soil absorbs moisture), and percent moisture in soil sample.

Factor	Effect on Soil Moisture

Check your answers by turning to the Appendix, Section 2: Activity 3.

Materials

- tape
- tacks
- string
- trowel
- compass
- clinometer
- light meter
- anemometer
- marking pens
- table tennis ball
- psychrometer
- water container
- centigram balance
- air and soil thermometers
- plastic bags to seal samples
- soup can with top and bottom removed

Procedure

- Select a site that has two different ecosystems very close to each other. Examples are coniferous and deciduous forests, a sandy-soiled region and an organically rich soil region, and a north-facing slope and a south-facing slope. Sloped sites are ideal.

- Visit the site and collect the following information. Fill in the following chart with your data. Some of the information will have to be processed. Take all measurements in the same manner. For example, do not measure the air temperature at one site 1 m above the ground and at the other site at ground level.

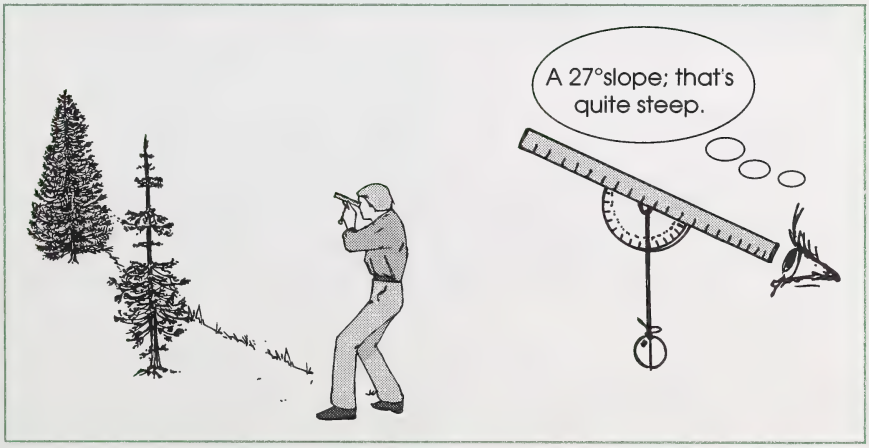
- Name and describe the ecosystem according to its vegetation.

- **Attitude**

  Use the compass to determine the direction that the slope faces.

- **Slope**

  Use the clinometer provided or build a clinometer as shown in the diagram from a protractor, string, weight, and a straight piece of wood. Site along the wood to an object as tall as you are. Pinch the string to the protractor and read the angle of the slope.


A 27°slope; that's quite steep.

- **Light Intensity**

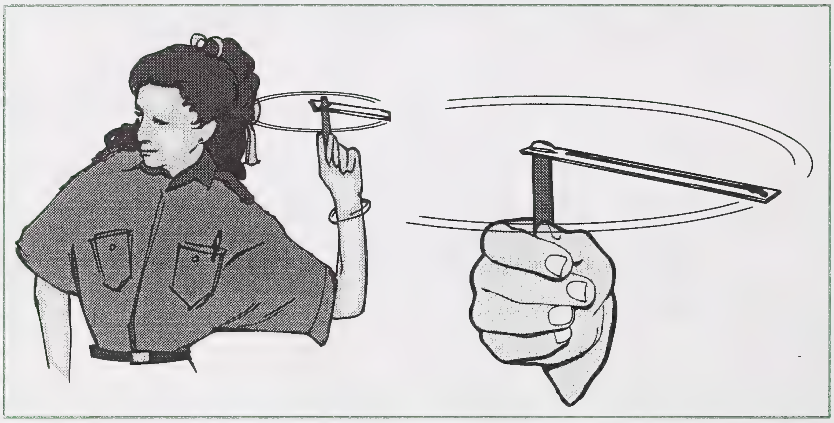
  Using a light meter, measure the light intensity following the instructions provided. If a light meter is not available, a camera with a built-in light meter can be used by standardizing the f-stop and then comparing the shutter speeds. If no light meter is available, make a qualitative description as to the amount of light present by using the terms *bright*, *shady*, *deep shade*, *cloudy*, and *hazy*.

- **Temperature**

  Measure the air and soil temperatures at the levels indicated on the observations table. Be sure to use the protective case for the thermometer when measuring the soil temperature.

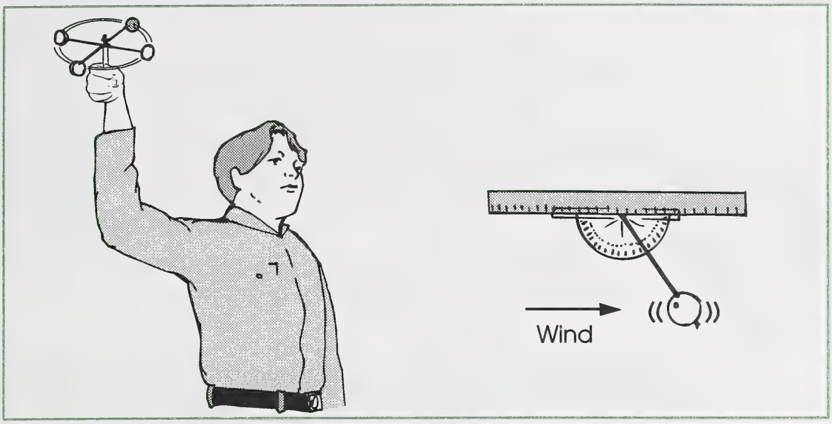
- **Relative Humidity**

  Measure the relative humidity using the sling psychrometer. Wet the wick covering the bulb of one thermometer and then spin the psychrometer for 1 min. Record the wet bulb and dry bulb temperatures and use a Relative Humidity Table supplied with the psychrometer to determine the relative humidity.



- **Wind Speed**

  Measure the wind speed using an anemometer. Follow the directions provided with the anemometer or construct a simple anemometer with a ruler, protractor, string, table tennis ball, and tape as shown in the following illustration. Note the wind speed using the angle in which the wind pushes the ball the farthest.



- **Percolation Test**

  For the percolation test, press the can firmly onto the ground and pour 200 mL of water in all at once. Measure the time it takes for the water to be absorbed by the ground.

- **Soil Moisture**

  The soil moisture percentage is determined by weighing the soil when it is collected and after it has been dried in a warm open area for one week. You can use the open-ended can from the percolation test to take uniform soil samples. Calculate the percent soil moisture using the following formula.

  % soil moisture = initial mass – dried mass ×100/initial mass

Observations

6. Fill in the following table with your observations.

Factor		Site 1 South Facing	Site 2 North Facing
Attitude			
Slope			
Light Intensity			
Air Temperature	Surface		
	2 m above surface		
Soil Temperature	Surface		
	10 cm below surface		
Relative Humidity	Surface		
	2 m above surface		
Wind Speed			
% Soil Moisture			

Part B

Use the data provided for you in the Appendix for this activity.

7. In a paragraph, restate the problem. Summarize your data; then answer the problem posed at the beginning of the activity. Be sure to use the concept of microclimate in your response.

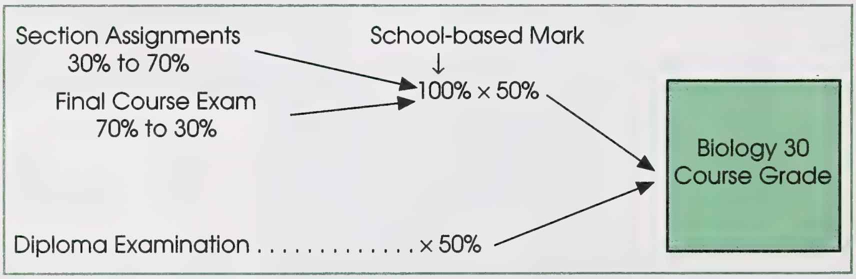
8. Beginning with bare soil, predict the order of plant communities that would grow at each site until a climax community is established.

Check your answers by turning to the Appendix, Section 2: Activity 3.

ACTIVITY

4 Preparing for Exams

You've made it. This is the last activity in your Biology 30 course. But don't celebrate yet. This may be the most important activity of all. Two exams are written at the end of this course. First you'll write the Biology 30 Final Exam. This is based on the modules you've studied and is much like a summary. Second, you'll write the Biology 30 Grade 12 Diploma Examination. This is written at an examination centre at various times during the year such as January and June. Your mark in Biology 30 will be based on a combination of section assignments, the final course exam, and the Diploma Exams. This following diagram explains how your marks are totalled.



This activity and the final course exam are good preparation for your Diploma Exam.

So, what kinds of questions are on the Diploma Exam?
What do I need to write the Diploma Exam?
How can I identify what is most important?
How can I study most effectively?
These are good questions. Let's approach them in order.

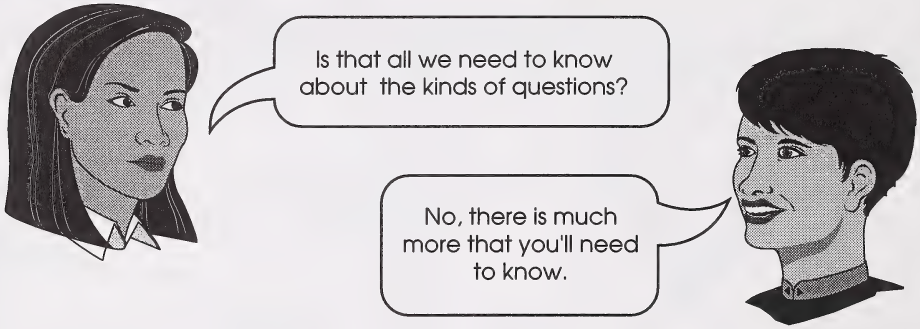
Diploma Exam questions will include multiple choice and written response types.

- **Multiple Choice**: With each question you are given several (usually four) alternative answers; listed by A., B., C., and D.; from which you choose the single best possible answer. Each multiple-choice question is worth one mark. You record your choice for each question by blackening a circle on a separate machine-score answer sheet provided.

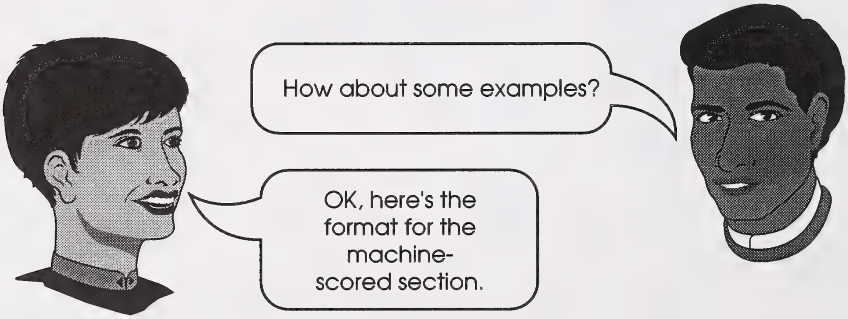
- **Numerical Response**: A numerical-response question is designed so that you must record your answer, but you do not show your work. There are two basic types of numerical-response questions: calculation questions and correct-order questions. Whichever type, you will be expected to record your answer on the same type of machine-scored answer sheet.

- **Written Response**: Written-response questions are multiple-mark questions in which you are expected to show all your work and organize and present your answer in a clear and precise manner. Marks may be given for clarity in the communication of your answer as well as the shown calculation work. You will be given several activity and assignment questions of this question style.

The multiple-choice and numerical-response questions are answered on a machine-scored answer sheet. So, you'll need a sharp HB pencil; it is a good idea to have two pencils. The written-response questions can usually be written in pencil or pen, but a pencil (with an eraser) saves on the use of correction fluid.


Is that all we need to know about the kinds of questions?
No, there is much more that you'll need to know.

The percent emphasis of machine-scored and teacher-scored questions, or multiple choice and written response, will be 70% and 30% respectively. The machine-scored section will contain both multiple-choice and numerical-response items.


How about some examples?
OK, here's the format for the machine-scored section.

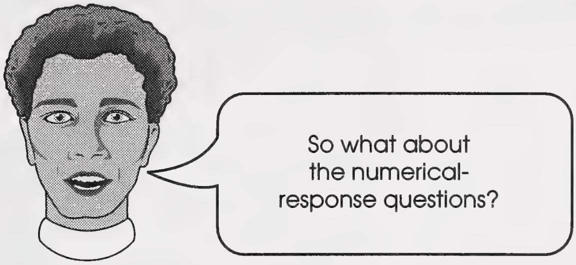
An ordinary multiple-choice question would look like this.

35. FSH is a secretion of the

- **A. testis**
- **B. anterior pituitary**
- **C. hypothalamus**
- **D. follicles**

Knowing the correct answer, you would record your response like this.

A	B	C	D
○	●	○	○


So what about the numerical-response questions?

Numerical-response questions may be correct-order questions or calculation questions. Here are some examples.

Correct-order Question and Solution

61. From the following list, determine and record the correct order of structures through which a sperm cell passes as it exits the male's body.

1. **Urethra**
2. **Vas deferens**
3. **Seminiferous tubules**
4. **Epididymis**

Knowing the correct answer, you would record your response like this.

Record 3421 on the answer sheet. →

Then shade in the numbers in the appropriate columns. →

3	4	2	1
⊙	⊙	⊙	⊙
⓪	⓪	⓪	⓪
①	①	①	●
②	②	●	②
●	③	③	③
④	●	④	④

Calculation Question and Solution

23. Find and record the q value in the Hardy-Weinberg formula when applied to a population of 200 animals where 72 individuals express the recessive trait.

Knowing the formula, you would do your calculations on rough paper as supplied in the Diploma Examination Booklet something like this.

- H-W formula is $p^2 + 2pq + q^2 = 1$
- q^2 represents recessive alleles.

$$\frac{72}{200} = q^2$$

$$q^2 = 0.36$$

$$q = \sqrt{0.36}$$

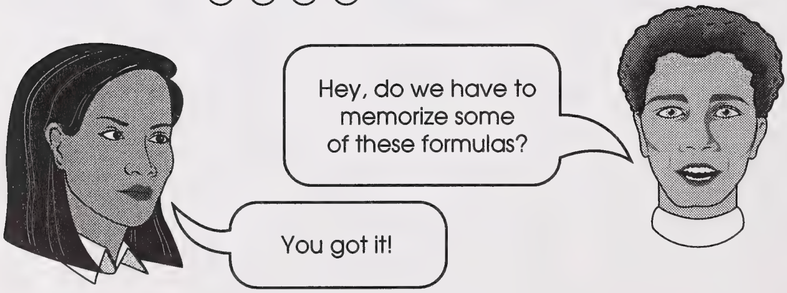
$$q = 0.6$$

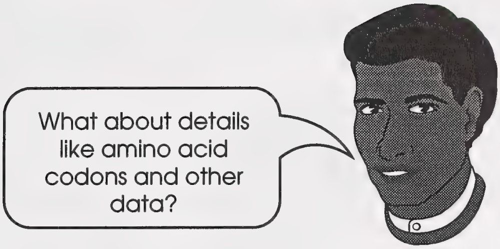
Then you would record your numerical response on the answer sheet like this.

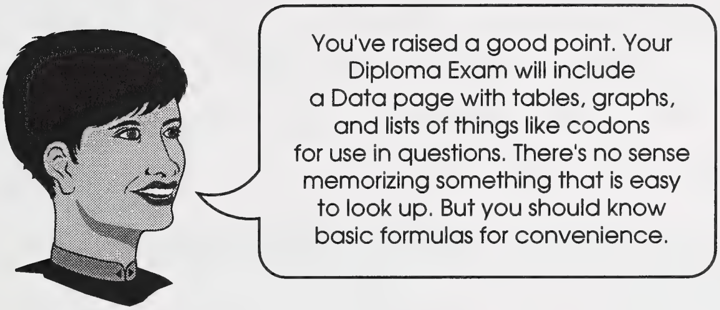
Record 0.6 here. →

Shade in the number like this. Notice how the decimal is indicated.

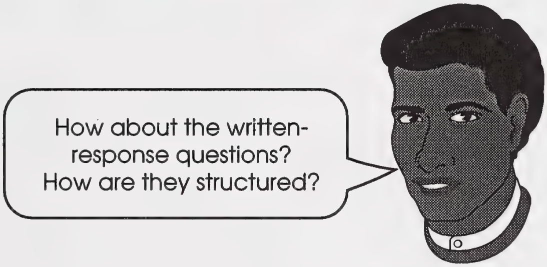
0	.	6	
⊙	●	⊙	⊙
●	⓪	⓪	⓪
①	①	①	①
②	②	②	②
③	③	③	③
④	④	④	④
⑤	⑤	⑤	⑤
⑥	⑥	●	⑥
⑦	⑦	⑦	⑦
⑧	⑧	⑧	⑧
⑨	⑨	⑨	⑨


Hey, do we have to memorize some of these formulas?
You got it!

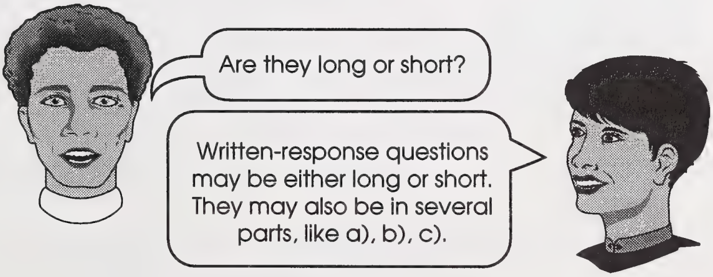

What about details like amino acid codons and other data?

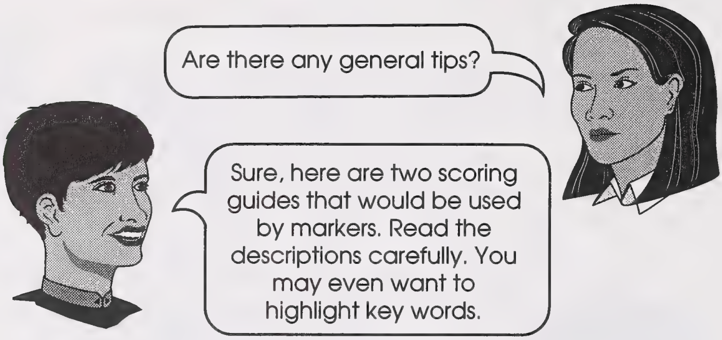

You've raised a good point. Your Diploma Exam will include a Data page with tables, graphs, and lists of things like codons for use in questions. There's no sense memorizing something that is easy to look up. But you should know basic formulas for convenience.

The Data page may be used in several questions. It may support multiple-choice, numerical-response, or written-response questions.


How about the written-response questions? How are they structured?

As you've read, written-response questions are multiple-mark questions where you show your work and compose an answer that is clear and concise. Marks are given for clear communication as well as for the correct answer.


Are they long or short?
Written-response questions may be either long or short. They may also be in several parts, like a), b), c).


Are there any general tips?
Sure, here are two scoring guides that would be used by markers. Read the descriptions carefully. You may even want to highlight key words.

Scoring Guides for Biology Diploma Examinations

The following is a scoring description used for a question about classical genetics.

Score	Scoring Descriptions for Scientific Knowledge
4 **Standard of Excellence**	The response is well organized and addresses all the major points of the question. Relevant scientific concepts and examples related to classical genetics are identified and interrelationships are explicit. The descriptions and/or explanations of these concepts are correct, well organized, and reflect thorough understanding and logical consistency of thought. The student uses complete sentences that make effective use of scientific vocabulary.
3	The response is organized and addresses most of the major points of the question. Relevant scientific concepts and examples related to classical genetics are identified and interrelationships are evident. The descriptions and/or explanations of these concepts are organized and reflect correct understanding. The student uses complete sentences that employ correct scientific vocabulary.
2 **Acceptable Standard**	The response addresses only some of the major points of the question, for example, autosomal but not sex-linked inheritance. Relevant scientific concepts and examples are identified but few interrelationships are shown. The student uses complete sentences but the use of appropriate scientific vocabulary is inconsistent.
1	The response addresses few major points of the question. Concepts are identified but interrelationships are not evident. The student describes the concepts in sentences, but organizational skills and scientific vocabulary are minimal.
0	The response does not address any of the major points of the question.

Score	Scoring Descriptions for Scientific Skills
4 **Standard of Excellence**	The response presents accurate and appropriate concrete evidence. Each step in the sequence of inheritance is clearly presented. The classic laws of unit factor inheritance and segregation are evident. Reciprocal crosses are used to provide evidence for the conclusion that parents make an equal contribution to the autosomal genetic makeup of the offspring. A tentative conclusion is presented but then evaluated and qualified in accordance with sex-linked inheritance.
3	The response presents appropriate concrete evidence. Each step in the sequence of inheritance is clearly presented. The classic laws of unit factor inheritance and segregation are evident. A tentative conclusion is presented, however, it is not supported by the evidence of reciprocal crosses. The conclusion is evaluated and qualified in accordance with sex-linked inheritance.
2 **Acceptable Standard**	The response presents evidence from an appropriate example of autosomal inheritance. The data includes the parental and F_1 generations only. Reciprocal crosses are not presented. A tentative conclusion is presented. This conclusion is not evaluated or correctly modified in accordance with sex-linked inheritance.
1	An example of autosomal inheritance is identified but not developed. A tentative conclusion is presented. The additional data concerning sex-linked inheritance is not related to the conclusion.
0	The response does not present appropriate data to support a conclusion.

- Written-response questions will be evaluated on how well the answer is communicated. Be clear and to the point. You may even want to restate part of the question in the beginning of your answer.

- Some questions will include concepts from more than one of the core concepts. For example, concepts from the nervous, hormonal, and reproduction topics may be linked.

- Written-response questions will require you to see relationships among concepts learned. For example, predator-prey relationships could be a part of succession.

- Some questions will require you to apply what you learned in new contexts. Case studies may be given as part of a question.

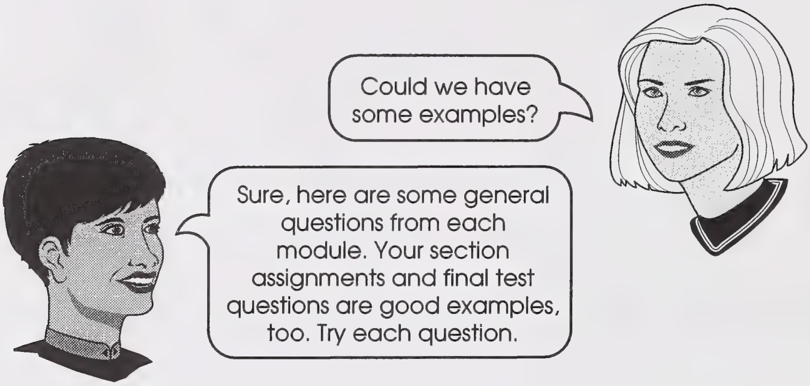
- Numerical answers are to be rounded only once, at the end of the question. Intermediate numbers are to be used as displayed on the calculator.

You are given credit for responses that are on topic, clear, concise, well written, and demonstrate the conventions of scientific language. Your assessment is based on three main criteria:

- Your response should answer the question asked and appropriately use the concepts you learned in Biology 30.

- Your response should be clear and logical, and organized in a meaningful manner. Shorthand should not be used because your notations may not be understood by all markers.

- Your response should use conventions of scientific language accurately. Proper terminology should be used.


Could we have some examples?
Sure, here are some general questions from each module. Your section assignments and final test questions are good examples, too. Try each question.

Nervous System

1. Suppose you stepped on a tack in your bare feet. Outline the major neural pathways that would be activated between stimulus and response.

Check your answers by turning to the Appendix, Section 2: Activity 4.

Hormones and Control

2. While riding her bike through a lane, Penny suddenly finds her path blocked by a car backing out of a garage. She jams on her brakes and nearly loses her balance, stopping just centimetres from the car's fender. The danger is past, but Penny finds her heart is still racing and her hands ache from suddenly squeezing her brakes. Describe the connection between the nervous and hormonal systems that have given Penny a racing heart rate and aching hand muscles.

Check your answers by turning to the Appendix, Section 2: Activity 4.

Human Reproduction

3. During the second month of pregnancy, the ovaries of a woman are surgically removed.

a. Describe the effect this would have on the reproductive hormonal system.

b. Predict the effect on the pregnancy.

4. a. Explain why only one corpus luteum may be found in the ovaries of a woman who has given birth to twins.

   b. Infer the identity of the twins as either paternal or fraternal (identical or not identical).

Check your answers by turning to the Appendix, Section 2: Activity 4.

5. Evaluate the difference in consequences between nondisjunction in mitosis and nondisjunction in meiosis.

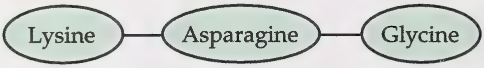
6. In a monohybrid cross of parents showing incomplete dominance, show how the frequency of phenotypes can be predicted using a Punnett square and the Hardy-Weinberg formula to get the same results.

Check your answers by turning to the Appendix, Section 2: Activity 4.

Use this data table for question 7. On a Diploma Exam this would be supplied on a Data Sheet.

Amino Acids	Codons
Alanine	GCU GCC GCA GCG
Arginine	CGA CGU CGC CGG AGA AGG
Asparagine	AAU AAC
Aspartate	GAU GAC
Cysteine	UGU UGC
Glutamate	GAA GAG
Glutamine	CAG CAA
Glycine	GGA GGC GGU GGG
Histidine	CAU CAC
Isoleucine	AUC AUU AUA
Leucine	UUA UUG CUU CUC CUA CUG
Lysine	AAA AAG
Methionine	AUG
Phenylalanine	UUU UUC
Proline	CCA CCC CCU CCG
Serine	UCG UCU UCA UCC AGU AGC
Threonine	ACU ACC ACG ACA
Tryptophan	UGG
Tyrosine	UAU UAC
Valine	GUU GUC GUA GUG
Terminator	UAA UAG UGA
Initiator	AUG

7. Gene X controls synthesis of a simple protein made of just three amino acids as shown.



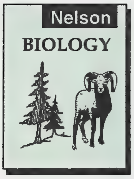
Unfortunately a mutation has altered this gene in the DNA code. The abnormal DNA code could not be found, but messenger RNA extracted from cell cytoplasm showed the following mutated sequence.

AUG AAG AAC UGA GGU

a. Identify and describe the mutation.

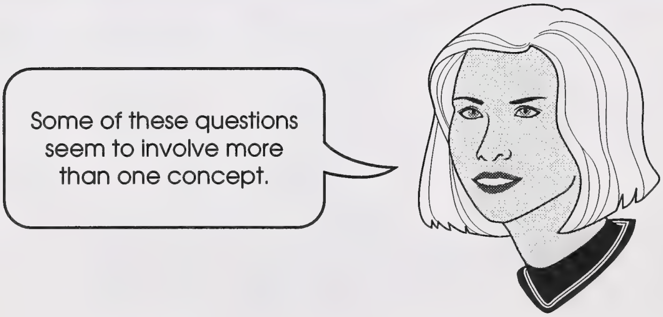
b. Correct the mutation by changing the DNA sequence. Demonstrate your proposed change by showing transcription and translation.

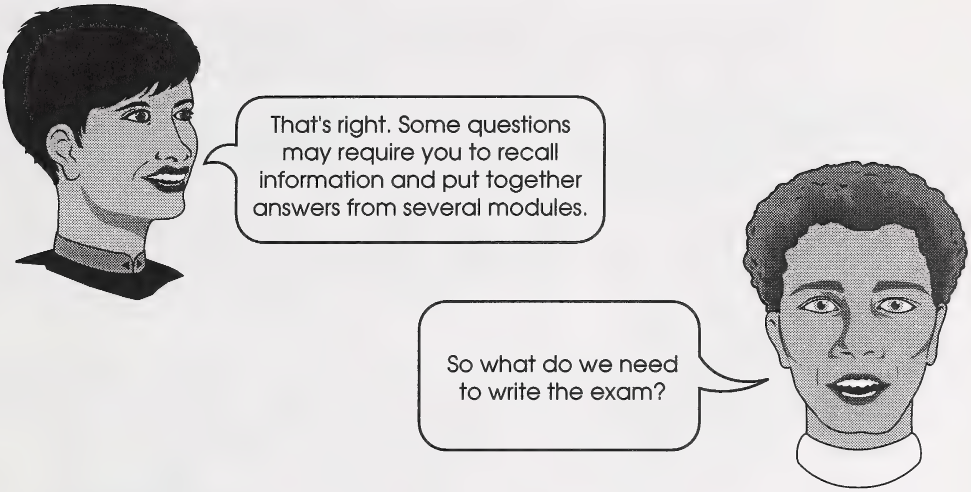
Check your answers by turning to the Appendix, Section 2: Activity 4.



8. Using the Case Study on pages 567 to 569 in your text as an example, (on a Diploma Examination a case study like this could be in the Data Booklet), explain how genetic disorders may demonstrate that evolution involves interactions between a gene pool and its environment. Include a description of the consequences of inheriting the homozygous or heterozygous genotype in your answer .

Check your answers by turning to the Appendix, Section 2: Activity 4.


Some of these questions seem to involve more than one concept.


That's right. Some questions may require you to recall information and put together answers from several modules.
So what do we need to write the exam?

The following is a list of materials you'll need:

- proper identification with your picture on it, such as a school card or a driver's licence
- calculator in good condition (You might consider extra batteries.)
- at least 2 sharp HB pencils
- an eraser
- small plastic metric ruler

Consider other things for your own comfort as needed, such as tissues or throat lozenges if you have a cold. A good night's sleep before the exam is a must.

So how do we identify what's most important?
And what's the most effective way to study?

Main concepts are the most important and the best place to begin studying. Look over the overviews and tables of contents of the modules. This will show you the main ideas. After you have identified the main concepts, you will need to identify specific details.

Details begin in the section introductions. As you look at the section introductions, ask yourself if they fit what you've learned. Do you feel you know something about these topics? You'll find on the Diploma Exam that questions are grouped around main concepts. This means that a main concept such as succession may be covered by both multiple-choice and numerical-response questions. So when studying these main concepts, watch for details such as structures and functions and cause and effect relationships.

Do you remember the science skills introduced in Module 1? Look for examples where you've learned to do something such as practising a skill. Practising skills can include such tasks as graphing, taking measurements, and doing calculations.

How about time management?

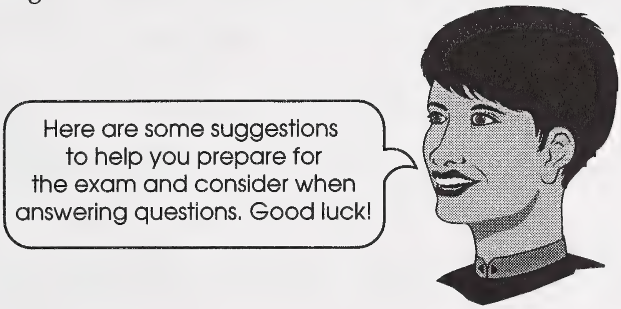
Time management is important in both effectively studying and writing the exam. Obviously you don't want to begin studying the night before the exam. Ideally, several weeks before the exam you should start getting organized. Look at the course and at your available time for study. There are seven modules. Most modules have two or three sections. Reviewing one section, including making a list of main ideas and vocabulary, and reviewing the section assignments and text, may take an entire evening. Identify on a calendar when you will be able to study. Pencil in the sections. Leave yourself some extra time for flexibility and unexpected events.

Time management and technique is also important when writing the Diploma Exam. You must write an examination during the specified time and may not hand in a paper until at least one hour of the examination time has elapsed. If you arrive more than one hour after an examination has started, you may not be allowed to write the examination. If you arrive late but within the first hour of an examination sitting, you may be allowed to write only at the discretion of the supervising teacher. You will have 2.5 h to write the exam. A multiple-choice question usually takes 30 s to 2 min to answer. Numerical-response questions may take a little longer, especially if calculations are required.

9. If the machine-scored to written-response ratio is 70:30, how much time will you likely spend in each section?

Check your answers by turning to the Appendix, Section 2: Activity 4.

A good rule of thumb would be to estimate 1 h on the multiple-choice and numerical-response questions and 1 h on the written-response questions. This leaves 0.5 h for review and checking.


Here are some suggestions to help you prepare for the exam and consider when answering questions. Good luck!

Preparing to Write a Science Diploma Examination – What You Should Do Before the Examination

- Prepare a course review schedule.
  - Design your schedule for the two-week period (minimum) before the examination.
  - Divide the course material into sections and indicate on the schedule the time blocks to be devoted to each section.
  - Take into account the examination blueprint available from your teacher (*Diploma Examinations Program Information Bulletin* for the course.) This blueprint indicates the relative importance (weighting) of each unit in the course. Note that course units are not equally weighted on the diploma examination.
  - Take into account units/concepts that you find most difficult, i.e., allocate more time for the review of these.
- Obtain and review examination schedules, rules, and policies.
  - Record the time and place of writing.
  - Note minimum and maximum writing times permitted.

  - Prepare to remain in the examination room for at least 2.5 h. (You may need to bring items such as tissues or cough drops.)

  - Identify materials allowed for writing each examination, such as pencils, pens, calculators, mathematical instruments, and a clear plastic ruler.

- Identify and collect examples of each type of question that will be asked.

  - Review the format of previous diploma examinations.
  - Learn the meanings of the key "directing" words.

- Make summaries and point-form outlines.

  - Distinguish between major concepts and factual details.

  - Identify essential skills that can be assessed on paper-and-pencil tests.

  - Review investigation results and procedures.

  - Identify connections between investigation reports, your notes, and your textbook.

  - Anticipate examples of connections between concepts and the "real world."

  - Prepare a glossary of important subject terminology.

  - Review formulas and equations and data tables.

  - Link each formula or equation with a calculation done on a previous test or assignment.

  - Identify any restriction on the use of each formula or equation.

- Use the following memory aids:

  - Colour code, underline, highlight, or jot keywords in margins.
  - Number points to be memorized.
  - Group word and idea associations.
  - Read keywords aloud, expressing their definitions in your own words.

Suggestions for Students When Writing Biology Diploma Examinations – What You Should Know When Writing Examinations

- Do not be afraid to answer each question even if you are not sure of the correct solution to the problem. A penalty is **not** given for guessing on the machine-scored section of the exam. Partial marks are often awarded for incomplete answers in the written-response section of the exam.

- If you are stuck on a question, mark the alternatives that you know are incorrect and choose from the ones that are left using logical guessing strategy. Think of the questions as challenges and cultivate a positive attitude about your ability to answer them.

- Scan the written-response, multiple-choice, and numerical-response sections of the examination before answering the questions. A question in one section of the examination may jog your memory about a question in another section.

- When first reading a multiple-choice question, locate and circle key words to help clarify the meaning of the question. Then hide the alternatives and try to formulate an answer of your own. Your answer may be very close to the correct alternative.

- If a multiple-choice question involves a calculation, do the calculation and select the alternative that is closest to your answer. A multiple-choice calculation is usually short. If you cannot do it in five minutes, your method is either inappropriate or incorrect. Go on to the next question.

- Diagrams on examinations are often labelled with numbers or letters. It may be useful to write in the names of the labelled structures or features that you can identify.

- When reading graphs, use a clear plastic ruler to more accurately extrapolate or interpolate data.

- Have a good reason for changing an answer. Do not change an answer on a hunch. Do not waste your time looking for patterns of As, Bs, Cs, or Ds in multiple-choice answers. There are none.

- You may not have time to write and edit a complete rough copy for each written-response question, but you should prepare an outline of your answer and use it as a guide when writing your good copy.

- When completing a written-response question, keep in mind the reader of your response. The reader will want to know how well you can do the following:

  - understand the problem or the mathematical/science concept
  - correctly use the mathematics involved
  - use problem-solving strategies and explain your answer and procedures
  - communicate your solutions and mathematical/science ideas

- Rewriting a statement of the question is often a good way to begin a written response. Conclude with a summary statement. Be sure you have clearly explained all assumptions and have verified your conclusions.

- Keep track of the time and pace yourself. Put a check mark by items that you are uncertain about and return to them if there is time at the end of the examination.

Follow-up Activities

If you have had difficulties in understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

In this section you have studied how communities change over time through a process called succession.

1. Do this matching question to reinforce the terms used in this section.

- climax
- primary
- secondary
- disruption
- seral
- pioneer
- microclimate

__________ a. type of succession that begins without soil

__________ b. type of succession that begins after a community has been disturbed

__________ c. small part of a habitat having different environmental conditions than the surrounding area

__________ d. intermediate communities during the pattern of succession

__________ e. the first organisms to colonize an area

__________ f. community that remains stable

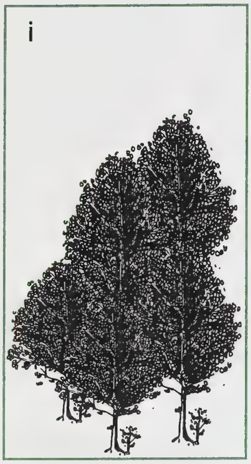
__________ g. catastrophical event that sets back succession

Check your answers by turning to the Appendix, Section 2: Extra Help.

2. Organize the following sketches into the order that shows the normal stages of succession. Match the correct number of the diagram to the following letter.

a. ______ b. ______ c. ______ d. ______

i



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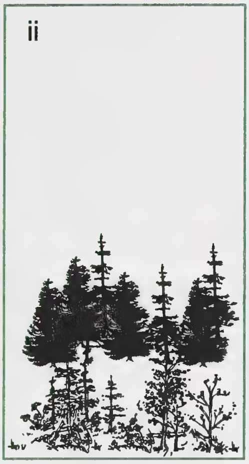

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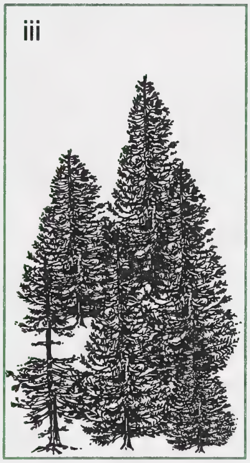

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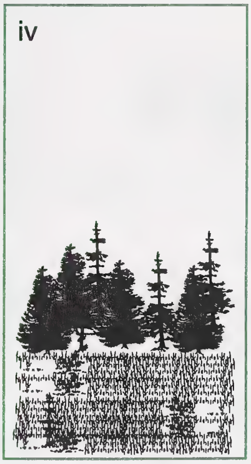


3. Some plants are at an advantage after a fire or other disturbance such as logging. For each example given, identify why those organisms have an advantage.

   a. grasses, fireweed, and aspen
   b. jackpines, lodgepole pines

To further review the concepts in succession, view the ACCESS Network video *Science Alive: The Spruce and The Hare* and then answer the following questions. Read over the questions first. You may wish to stop the video to answer a question.

4. Describe the preferred habitat of the snowshoe hare.

5. Under what circumstances would this habitat occur?

6. Compare the time it takes aspen trees to mature to spruce trees.

7. Why do aspen trees appear before spruce trees?

8. The foresters use a method called stand tending to give the spruce trees a competitive advantage over the aspens. Does this speed up or slow down the normal pattern of succession? Explain your answer.

Check your answers by turning to the Appendix, Section 2: Extra Help.

Enrichment

Do one or more of the following.

1. Imagine and compare the pattern of primary succession on two new volcanic islands. One is 10 km from the mainland and the other is 200 km from the mainland.

2. The National Film Board has produced an excellent video on fire ecology, which deals with the issue of fires in the national parks in Alberta. Its title is *Ashes to Forest* and focuses on experimental burning in Banff. Obtain and view this video. Then answer the questions that follow.

   a. How are most forest fires started?

   b. Identify the motives for fighting forest fires.

   c. What role does fire play in shaping the environment of Wood Buffalo National Park?

   d. What would happen if nutrients were not returned to the soil after a forest fire?

   e. Approximately what percentage of seedlings will mature to form a climax forest?

   f. How do grizzly bears benefit from burned areas?

   g. If a jack pine tree is attacked by pine beetles and is killed, why can't its seeds reproduce?

   h. Which two species of trees will replace insect-killed pines?

   i. How did the pines modify the environment to assist the growth of the spruce seedlings?

   j. Show the relationship between the drop in animal populations in Banff National Park and the policy of suppressing forest fires.

   k. Defend the idea behind setting controlled fires within Banff National Park.

Check your answers by turning to the Appendix, Section 2: Enrichment.

3. Write to the Pine Ridge Tree Nursery in Smoky Lake for information on replanting. It is a tremendous facility that produces many of the seedlings used to replant Alberta's forests. The techniques used are state of the art. Research is ongoing into producing genetically superior seedlings more efficiently.

   Pine Ridge Tree Nursery
   General Delivery
   Smoky Lake, Alberta
   T0A 3C0

   If you would like to consider working in silviculture as a career, educational opportunities exist at regional colleges, NAIT, SAIT, and at the University of Alberta. Contact them for information.

Check your answers by turning to the Appendix, Section 2: Enrichment.

Conclusion

In this section you learned that communities seldom stay constant. The change which they undergo is called succession. The pattern of succession is dependant on the interaction of the biotic and abiotic factors that create a unique microclimate to that area. Human activities may disrupt the pattern of succession. Some human activities, such as agriculture and urban sprawl, prevent succession from occurring.

Section 2 Assignment: Succession

㊵

Response Page Setup

Review the Evaluation information found in the introductory pages of this module.

It is important to number and clearly identify each page with the following information at the top:

Biology 30 – Module 7   Section 2 Assignment   Page #   Name and ID#

Be sure to write legibly. Leave a wide left margin and number all of your pages.

Carefully read each of the following multiple choice questions and decide which of the choices **best** completes the statement or answers the question. Each question is worth 1 mark.

1. The first organisms to enter a barren area are known as

   A. climax species
   B. pioneer species
   C. epiphytic species
   D. seral species

2. If the dominant species of plants in a climax forest community are removed, the area will be repopulated first with

   A. members of the same species removed
   B. lichens and mosses
   C. some plants of an earlier seral stage
   D. decomposer organisms

3. Succession proceeds through a number of recognizable stages. In a sequence that probably occurs over most of northern Alberta, predict the missing community in the following pattern.

   soil → grasses → shrubs → ________________ → spruce forest

   A. mosses
   B. aspen forest
   C. pines
   D. lichens

4. Successional changes take place at the

   A. community level
   B. population level
   C. level of individual organism
   D. biosphere level

5. The climax community of an ecosystem is determined by

   A. soil only
   B. climate only
   C. producers only
   D. a combination of soil, climate, and producers

Use the following information to answer questions 6 and 7.

The following data was collected on the number of individuals in 1 km^2 area.

	1990	1991	1992	1993	1994
Plant 1 × 100	10	15	35	47	65
Plant 2 × 100	75	52	27	8	2
Plant 3 × 100	10	11	12	11	13
Animal X	5	1	8	27	2
Animal Y	0	2	6	15	50
Animal Z	15	12	2	0	0

6. Which of the following plants will most likely form the climax vegetation?

   A. Plant 1
   B. Plant 2
   C. Plant 3
   D. cannot be determined

7. Which organism was probably introduced into the community?

   A. Plant 2
   B. Plant 3
   C. Animal X
   D. Animal Y

8. Which of the following is the strongest characteristic of climax communities?

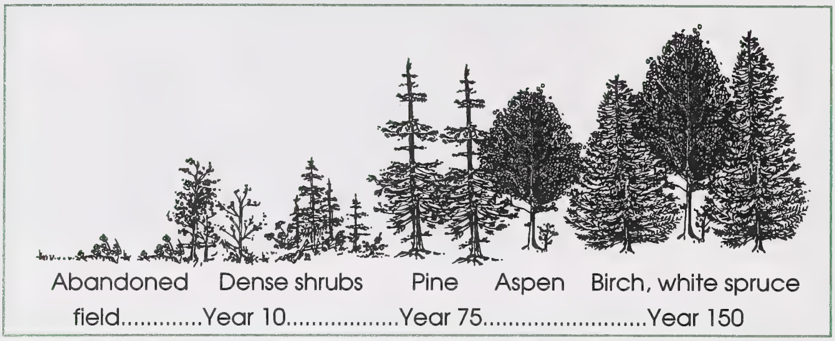
   A. a gradual increase in biomass
   B. an annual increase in net productivity
   C. maximum efficiency at trapping energy
   D. high species diversity

9. A microclimate is controlled mostly by differences in land surface and

   A. elevation
   B. vegetation
   C. latitude
   D. cloud cover

Use the following information to answer questions 10 to 14.

The diagram shows the changes over time in the vegetation of a farmed area which was abandoned.



10. The preceding diagram illustrates

    A. primary succession
    B. secondary succession
    C. tertiary succession
    D. pioneer plants

11. The most stable stage would most likely be the

    A. herb community
    B. shrub community
    C. dense shrub community
    D. birch, and white spruce community

12. The most diversity in terms of species composition would be expected in the

    A. herb community
    B. shrub community
    C. pine community
    D. birch, and white spruce community

13. Which of the following tends to produce more organic plant material than it uses?

    A. herb community
    B. shrub community
    C. dense shrub community
    D. birch, and white spruce community

14. Jack pine forests are adapted to recover after a forest fire because

    A. their cones are insulated against the fire and will not burn
    B. they are able to regrow from fibrous surface roots
    C. they produce light seeds that travel large distances to recolonize the burned area
    D. the heat from the fire opens the cones

15. Chaos theory is a mathematical modelling method that attempts to

    A. find order in apparently random events
    B. determine specific population levels in an ecosystem
    C. calculate the value of species diversity in an ecosystem
    D. predict populations levels many years into the future

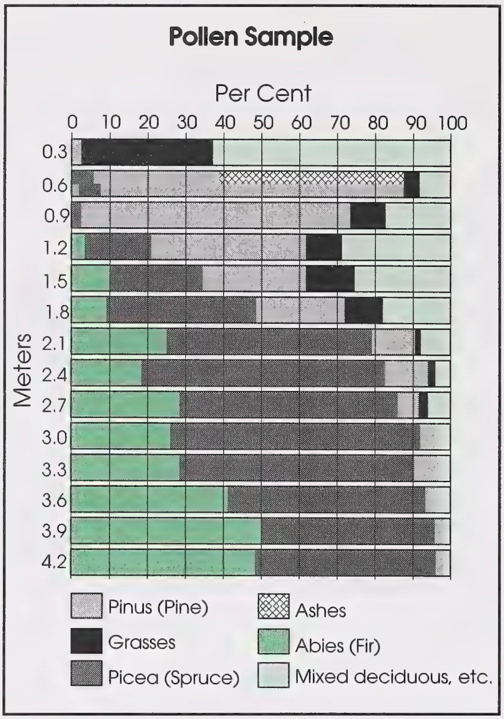
16. A student was interested in the development of shoots in aspen (*Populus tremuloides*.) The student staked off an area with a 10 m radius around two trees growing in the same area. In early May the student went out and picked a large portion (20%) of the swollen buds off one tree. The other tree was left untouched. In August, the student returned to the site and counted the number of shoots growing from surface roots within each staked out area. The results were 56 shoots around the tree that was untouched and 185 shoots for the tree that had some buds removed.

    a. Write a problem that clearly identifies the manipulated and responding variables. **(1 mark)**

    b. Using an "if … then" statement, write an hypothesis for this experiment. **(2 marks)**

    c. Analysis of aspen groves downwind from heavy tent caterpillar infestations show an increase in the amount of annual number of shoots produced. Tent caterpillars favour the aspen as a food source. Does this information support or refute your hypothesis? Explain. **(2 marks)**

Use the following graph to answer question 17.



17. The previous graph shows an analysis of pollen collected at various soil depths from a site near Brooks, Alberta. The samples were collected by drilling into the earth to the maximum depth and then removing the entire core sample. The total depth of the sample relates to the recession of the last glacial period, approximately 11 000 years ago.

    a. Are the earliest samples represented by the top or the bottom of the sample? Explain. **(1 mark)**

    b. From the information summarized in the graph, describe the probable change in communities in this region over the last 11 000 years. Justify your answer. **(3 marks)**

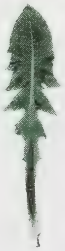
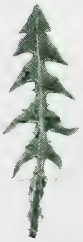
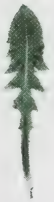
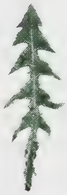
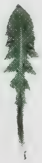
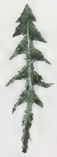
    c. Propose a reason as to why these climax communities changed in the pattern presented. **(2 marks)**

    d. At 0.6 m, the sample shows a variation from the pattern established. How would you account for this? **(2 marks)**

18. a. The Cyprus Hills in southern Alberta are at a higher elevation and support a climax community of lodgepole pines. If this area were to experience a major forest fire, describe the seral stages of succession that would occur after the fire. **(2 marks)**

    b. Due to an increased amount of volcanism reducing the intensity of solar radiation, the climate in this region becomes cooler and moister for about 100 years. Based on the information in the graph in question 17, predict the climax community that would be present in the Cyprus Hills region 100 years from now. **(2 marks)**

Use the following information to answer question 19.

	Shape		Total leaf mass per plant		Colour	
	Origin North	Origin South	North	South	North	South
Exposure North			28.4 g 6 leaves	27.6 g 8 leaves	Dark green	Dark green
East			24.7 g 14 leaves	25.8 g 12 leaves	Mid-shade	Mid-shade
South			23.5 g 18 leaves	22.9 g 17 leaves	Light green	Light green

An observant student noticed that the leaves of dandelions growing on the north side of her house were significantly different in size and shape than the leaves of dandelions growing on the south side of the house. (See the previous diagram.) Puzzled as to why there would be such a difference, she dug up some specimens from either side of the house and potted them. After a one week period, she removed the leaves by clipping them at the surface of the soil. She then placed one north and one south specimen in a northern exposure, a southern exposure, and an eastern exposure. The plants were examined daily and at the end of one month the leaves were removed and analysed as to their morphology (shape) and mass. Qualitative results were collected and the data is summarized in the preceding table. On the basis of this information, answer the questions that follow.

19. a. What specific relationship was the student attempting to determine? **(1 mark)**

    b. Identify three variables that she would have kept constant if the results were to be considered reliable. Explain. **(3 marks)**

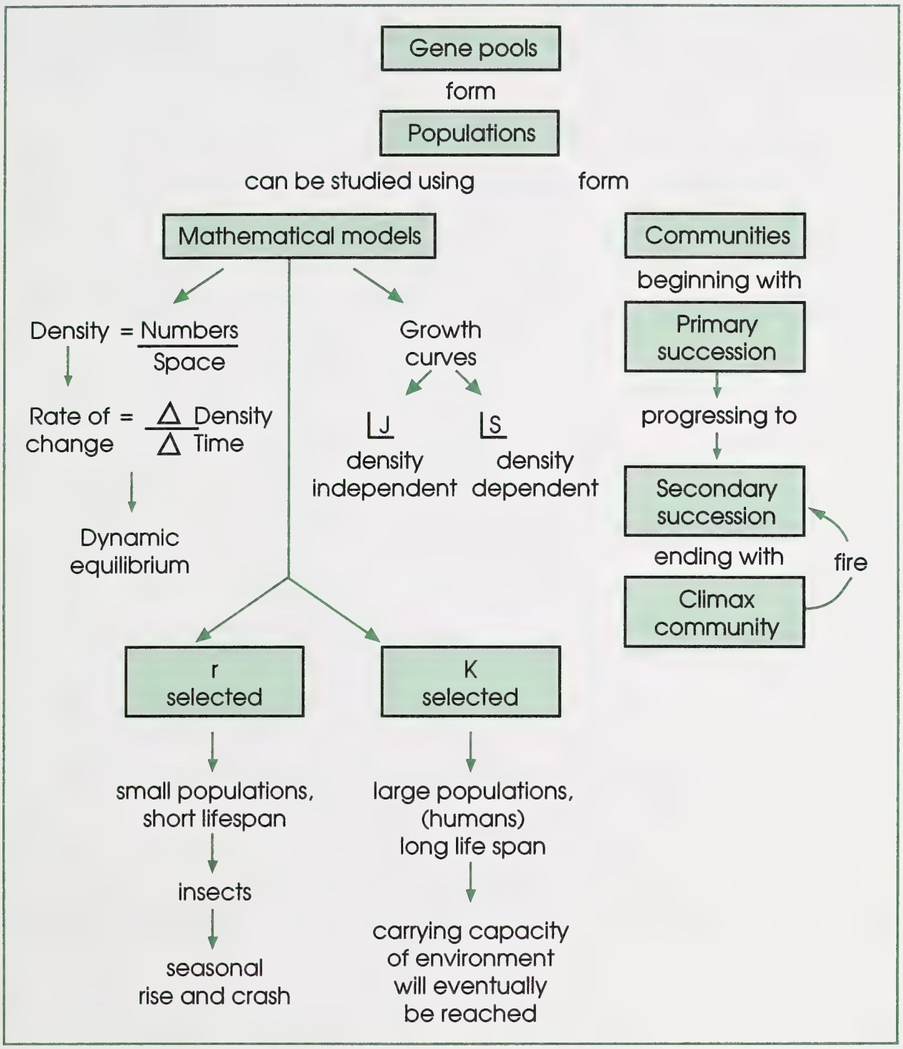
    c. According to the data, what is the apparent relationship between the environment the plants grow in and their morphological (structural) differences? **(3 marks)**

    d. Propose a method that could be added to the outlined procedure to remove the possibility of genetic variation. **(1 mark)**

MODULE SUMMARY

In this module you studied how populations are structured and how they change over time. You learned how population changes are described in quantitative terms using graphs and formulas. A combination of abiotic and biotic factors, including populations, was presented as succession. Succession is a natural process that will occur continually without human intervention. However, human activities can have a strong effect on succession as illustrated by the influence of fire and logging. Imagine the impact of agriculture.

The module concluded with an activity to help you prepare for your final test and Diploma Examination. It is hoped that you've enjoyed your studies of Biology 20 and 30. Knowledge and appreciation of the environment is vital if humans are to co-exist with other forms of life in the biosphere.



To ensure that all of your work has been completed in a satisfactory manner, check off the items in the following list:

- ☐ Section 1 Assignment has been completed.
- ☐ Section 2 Assignment has been completed.
- ☐ Your responses are organized and neat, with room for teacher comments.
- ☐ All your response pages are numbered consecutively and identified with this heading.

Biology 30 – Module 7 Section # Assignment Page # Name and ID #

COURSE SURVEY FOR BIOLOGY 30

Please evaluate this course and return this survey when you have completed your last module assignment. This is a course designed in a new distance-learning format, so we are interested in your responses. Your constructive comments will be greatly appreciated, as future course revisions can then incorporate any necessary improvements.

Name ______________________ Course ______________________

Address ______________________ Age ☐ under 19 ☐ 19 to 40 ☐ over 40

______________________ File No. ______________________

______________________ Date ______________________

Design

1. This course contains a series of module booklets. Do you like the idea of separate booklets?

____

____

2. Have you ever enrolled in a correspondence course that arrived as one large volume?

☐ Yes ☐ No If yes, which style do you prefer?

____

____

3. The module booklets contained a variety of self-assessed activities. Did you find it helpful to be able to check your work and have immediate feedback?

☐ Yes ☐ No If yes, explain.

____

____

4. Were the questions and directions easy to understand?

☐ Yes ☐ No If no, explain.

____

____

5. Each section contains Follow-up Activities. Which type of follow-up activity did you choose?

   ☐ mainly Extra Help
   ☐ mainly Enrichment
   ☐ a variety
   ☐ none

   Did you find these activities beneficial?

   ☐ Yes ☐ No If no, explain.

6. Did you understand what was expected in the section assignments?

   ☐ Yes ☐ No If no, explain.

7. The course materials were designed to be completed by students working independently at a distance. Were you always aware of what you had to do?

   ☐ Yes ☐ No If no, provide details.

8. Suggestions for audiocassette and videocassette activities may have been included in the course. Did you make use of these media options?

   ☐ Yes ☐ No Comment on the lines below.

Course Content

1. Was enough detailed information provided to help you learn the expected skills and ojectives?

   ☐ Yes ☐ No Comment on the lines below.

2. Did you find the work load reasonable?

☐ Yes ☐ No If no, explain.

____

____

3. Did you have any difficulty with the reading level?

☐ Yes ☐ No Please comment.

____

____

4. How would you assess your general reading level?

☐ poor reader ☐ average reader ☐ good reader

5. Was the material presented clearly and with sufficient depth?

☐ Yes ☐ No If no, explain.

____

____

General

1. What did you like least about the course?

____

____

2. What did you like most about the course?

____

____

Additional Comments

____

____

____

Only students enrolled with the Alberta Distance Learning Centre need to complete the remaining questions.

1. Did you contact the Alberta Distance Learning Centre for help or information while doing your course?

   ☐ Yes ☐ No If yes, approximately how many times? ______

   Did you find the staff helpful?

   ☐ Yes ☐ No If no, explain.

   ____

   ____

2. Were you able to fax any of your assignment response pages?

   ☐ Yes ☐ No If yes, comment on the value of being able to do this.

   ____

   ____

3. If you were mailing your assignment response pages, how long was it taking for their return?

   ____

   ____

4. Was the feedback you received from your correspondence teacher helpful?

   ☐ Yes ☐ No Please comment.

   ____

   ____

   ____

   ____

Thanks for taking the time to complete this survey. Your feedback is important to us. Please return this survey with your last module assignment.

Instructional Design and Development
Alberta Distance Learning Centre
Box 4000
Barrhead, Alberta
T0G 2P0

Appendix

Glossary

Suggested Answers

Science Skills Spreadsheet

Glossary

age pyramid: a graph used to organize age and gender of a population

chaos theory: a mathematical method of trying to find order in apparently random events

fecundity: the condition of being fertile

Suggested Answers

Section 1: Activity 1

1. - **Review question 1**: The three characteristics of a population are its geographic range, its habitat, and its size. Other characteristics include its distribution and ecological niche.
   - **Review question 2**: A population is a group of individuals of the same species living in the same place at the same time. A community is composed of all of the populations of plants and animals living in the same place at the same time.
2. - **Review question 3**: An animal's geographic range is a region where organisms of the species have been spotted. By contrast, its habitat is the area where organisms of the species most successfully live. For example, bears are found all across Canada; however, their habitat is forests. They are not found in cities or in the middle of lakes.
3. - **Review question 4**: An ecological niche refers to a population's role within its community. This role includes all the biotic and abiotic factors that the population influences and that influence the population.
4. - **Review question 5**: A population can be distributed in several ways. A clumped distribution is a distribution pattern where a population is concentrated in several distinct areas throughout its habitat. This uneven distribution is caused by abiotic factors. Random distribution of a population is uncommon, but occurs when members of the population have neither attraction nor repulsion between each other. Uniform distribution occurs when the habitat is uniform and there is uniform competition among individuals for raw materials.
   - **Review question 6**: Your answers will vary depending on where in the province you live and what type of area you choose. In northern Alberta a uniform distribution would be found in a pine forest. This would be due to competition for water. A clumped distribution for northern Alberta would be ducks found feeding on a pond. In southern Alberta a uniform distribution would be prairie grass in a large field. A clumped distribution would be the arrangement of trees around a slough or pronghorned antelope in a valley.
5. The population statement that you developed will be unique for your area of the province. If it states the number of organisms, the location, and the time, your statement is satisfactory. Two examples are
   - "There are 1000 pine trees in a section of land near Athabasca in July of 1993."
   - "There are 50 pronghorned antelope living in a valley near Lethbridge in November of 1993."

6. Population density describes the number of organisms living in a defined amount of space, for example, five whitetailed deer per square kilometre.

7.
- **Review question 7**: The density of the meadow vole population is 3.9 meadow voles per hectare.

  $D = N/S = 78/20 = 3.9$ meadow voles per hectare.

- **Review question 8**: The rate of change in density of a population is defined as the amount by which the density of population changes over a stated period of time. The population changes but the area occupied by the population remains the same. A period of time is included.

8.
- **Review question 9**: $R = \Delta D / \Delta t = (3-15)/(1991-1981) = -12/10 = -1.2$

  The rate of change in density of the lemming population is –1.2 lemmings per hectare per year from 1981 to 1991. Thus, the lemming population is decreasing.

9. The following are four factors that influence population size:

   - natality – increase in population
   - mortality – decrease in population
   - immigration – increase in population
   - emigration – decrease in population

10.
- **Review question 10**: The population growth rate for the puffin colony is calculated as follows:

$$\begin{aligned} PG &= \left[(b+i)-(d+e)/n\right]\times 100 \\ &= \left[(15\,000+175\,000)-(10\,000+160\,000)/200\,000\right]\times 100 \\ &= +10\% \end{aligned}$$

- **Review question 11**: Dynamic equilibrium is a condition where a population size fluctuates between certain limits. The average population tends to remain stable over time.

- **Review question 12**: An open population is a population in which density is controlled by internal and external factors such as a natural population of pronghorn antelope on the open prairie. Factors include natality and mortality, as well as immigration and emigration. A closed population is one in which the density of the population is controlled only by internal factors. Natality and mortality are the only interactions. An example of a closed population could be animals in a park or zoo or plants in a garden.

11.
- **Review question 13**: The growth curve of a closed population is characterized by four distinct phases. These stages include the lag phase, a period of inactivity, during which time the population is thought to adjust to the environment before beginning reproduction. The next phase is the growth phase, during which the population increases exponentially. At some point the growth rate slows, and the population enters the stationary phase where birth rates equal death rates. As wastes accumulate and nutrients decrease, the population enters the death phase. Organisms die at a constant rate. The entire population may die out.

12. The puffin population increase is calculated using $I = R \times N$. $I = 10\% \times 200\,000 = 20\,000$. The increase to the population is 20 000 puffins in 1991, making the total 220 000 puffins. For 1992, $I = 10\% \times 220\,000 = 22\,000$. Total population would be 242 000.

13. A population should behave normally if the factors that affect the population growth remain constant. There are, however, numerous extraneous factors which could alter the predicted course of events. There could be a pollution problem, a new disease could affect breeding, the food supply could decrease causing less natality and immigration, or the factors could change so that the population begins to rise at a faster rate than calculated. Do you remember the article on raccoons and nesting sea birds in Module 6?

Section 1: Activity 2

1. - **Textbook question a**: This is a difficult question to answer without knowledge of Newfoundland mammals. Undoubtedly new species of shrews evolve from previous species, but just because the masked shrew evolved in one area, it need not evolve in another area. Recall the bison lineages you studied in Module 6.

   - **Textbook question b**: This is likewise a challenging question but since the masked shrew is not a native species to Newfoundland, it is quite possible there might not be any natural predators already there.

   - **Textbook question c**: Trapping the entire area is not only time consuming, but the trapping procedure also places the small mammals at risk. Within reasonable limits the samples should show trends that occur in the entire population.

   - **Textbook question d**: By keeping the size constant and setting traps in the same location, variables were controlled as much as possible. Differences in the populations would be due to natural factors and not changes in experimental design.

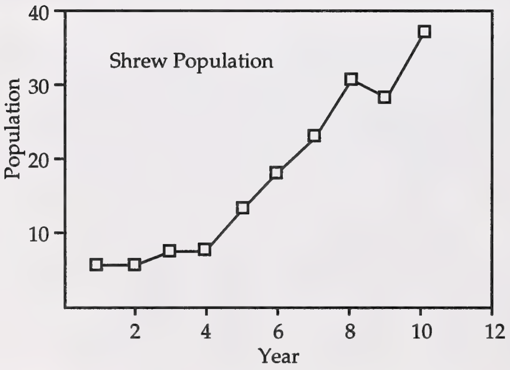
   - **Textbook question e**: The biologist marked each trapped shrew to avoid counting the same shrew twice and to provide some data to monitor migration.

   - **Textbook question f**: Four trapping stations were used to obtain a larger sample size. Differences from one site to another could be reduced by increasing the number of sites.

2. - **Textbook question g**:

Year	1	2	3	4	5	6	7	8	9	10
Total	5	5	7	7	13	18	23	31	29	38
Average	1.3	1.3	1.8	1.8	3.3	4.5	5.8	7.8	7.3	9.5

3. - **Textbook question 7**:



4. - **Procedure question h:** Quadrat 4 has the greatest number of shrews. This area may have the greatest density of larch and spruce trees, and hence the greatest number of sawflies. The sawflies provide food for the shrew. You might also consider preferred reproductive sites or an area that has minimal competition from other small mammals. Vegetation or access to water might play a role.

   - **Procedure question i:** If a best-fit curve is used, the general trend would show continuous increases in population; however, two years did not produce an increased growth.

   - **Procedure question j:** Years 1 to 4 appear to be the lag phase, while years 5 to 10 appear to be the growth phase.

   - **Procedure question k:** Two possible answers are the growth phase continuing or the beginning of the stationary phase. In other words, the population could continue to increase or begin to stabilize.

   - **Procedure question l:** The drop in population may be related to food sources declining, interspecific competition, intraspecific competition, increased parasitism, or predation. Other variables could be considered, such as weather or climate. A combination of factors is also possible.

   - **Procedure question m:** Interspecific competition may have occurred. The more similar the animals, the greater is the competition.

5. - **Application question 1. (a):** $20\text{ m} \times 20\text{ m} = 400\text{ m}^2$.

   - **Application question 1. (b):** $10\,000\text{ m}^2 = 1\text{ ha}$

     $$\frac{400\text{ m}^2}{10\,000\text{ m}^2/\text{ha}} = 0.04\text{ ha}$$

   - **Application question 1. (c):** Release area $= 10.0\text{ km}^2$

     $$1\text{ km}^2 = 100\text{ ha}$$

     $$10\text{ km}^2 = 1\,000\text{ ha}$$

   - **Application question 2:** Each quadrat is 0.04 ha; therefore, to find the average: $(12 + 7 + 4 + 15)/4 = 9.5$ shrews per 0.04 ha or 237.5 shrews per ha.

   - **Application question 3:** 237.5 shrews/ha, total area = 1 000 ha, or 237 500 shrews.

   - **Application question 4:** Each shrew is not counted; the population is determined by a random sample. The sample assumes that the animals are equally distributed in each quadrat.

   - **Application question 5:** Density (*D*) can be calculated by the average number of shrews per quadrat. For Year 1 density is 5 shrews/4 quadrats or 1.25 shrews/quadrat. For Year 5 density is 13 shrews/4 quadrats or 3.25 shrews/quadrat. For Year 6 density is 18 shrews/4 quadrats or 4.5 shrews/quadrat. For Year 10 density is 38 shrews/4 quadrats or 9.5 shrews/quadrat.

The density per quadrat can be changed to hectares (each quadrat is 0.04 ha).

$$D_{\text{Year 1}} \frac{1.25 \text{ shrews/quadrat}}{0.04 \text{ ha/quadrat}} = 31.25 \text{ shrews/ha}$$

$$D_{\text{Year 5}} \frac{3.25 \text{ shrews/quadrat}}{0.04 \text{ ha/quadrat}} = 81.25 \text{ shrews/ha}$$

$$D_{\text{Year 6}} \frac{4.5 \text{ shrews/quadrat}}{0.04 \text{ ha/quadrat}} = 112.5 \text{ shrews/ha}$$

$$D_{\text{Year10}} \frac{9.5 \text{ shrews/quadrat}}{0.04 \text{ ha/quadrat}} = 237.5 \text{ shrews/ha}$$

To calculate the rate of density change between years 1 and 5 use $R = \frac{\Delta D}{\Delta t}$. Review page 581 in your text if necessary.

$$\begin{aligned} R &= \frac{\Delta D}{\Delta t} \text{ or } \frac{D_{\text{Year 5}} - D_{\text{Year 1}}}{5-1} \\ &\frac{81.25 - 31.25}{5-1} \\ &= \frac{50.0}{4} \text{ or } 12.5 \end{aligned}$$

The rate of density change is 12.5 shrews/ha/yr. To calculate the rate of density change between years 6 and 10 use the same method.

$$\begin{aligned} R &= \frac{D_{\text{Year 10}} - D_{\text{Year 6}}}{10-6} \\ &= \frac{237.5 - 112.5}{10-6} \\ &= \frac{125.0}{4} \text{ or } 31.25 \end{aligned}$$

The rate of density change is 31.25 shrews/ha/yr. The greater population change occurred between years 6 and 10.

- **Application question 6**: Newfoundland is geographically isolated from other land masses so small mammals may not easily spread to Newfoundland. Climate and vegetation may also be factors impeding greater variety in species.

Section 1: Activity 3

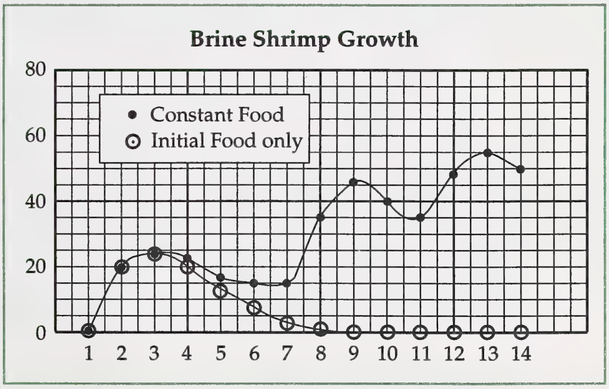
1. One problem could be, "How does food, as a limiting factor, affect the growth curve of brine shrimp?"

2. One hypothesis would be that if food was limited, the population growth will be slow. Insufficient nutrients may reduce growth to zero.

3. The following is a chart of population growth for brine shrimp. Your chart will have your own values. If you were unable to obtain values for the experiment, the following can be used.

Numbers of Brine Shrimp		
Time(d)	**Constant Food**	**Initial Food Only**
1	0	0
2	20	20
3	24	24
4	22	20
5	18	13
6	15	9
7	15	3
8	35	0
9	46	0
10	40	0
11	35	0
12	49	0
13	55	0
14	50	0

4. Your graph might look something like this.



5. The reason why the food was supplied only once was so that different growth curves could be analysed. One was not affected by the limiting factor of food and the other was. The amount of food in the environment is the manipulated variable in the investigation.

6. The population of shrimp that had a continual supply of food grew at a fast rate and then fluctuated around the carrying capacity. The population of shrimp that had food supplied only once grew at a fast rate and then quickly declined.

7. The S-shaped curve is represented by the test tube supplied with a constant supply of food. The population remained relatively stable because the shrimp had a food source; those that died were replaced by reproduction.

8. The stationary phase in a population can be described as the carrying capacity of the population's environment.

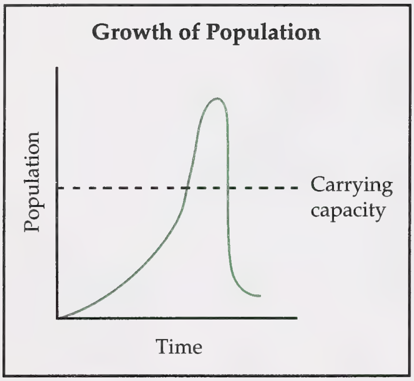
9. A new carrying capacity was reached because an additional nutrient was supplied. Now more organisms can be supported.

10. - **Review question 14**: The carrying capacity of an environment is the maximum number of organisms of a species that an environment can support. The term *biological potential* describes the maximum number of offspring that can be produced by a species under ideal circumstances. *Environmental resistance* is a term used to describe all of the environmental factors that negatively affect population numbers.

11. Humans will usually have one child per birth, only seldom will two or more children be born. The capacity for survival is very high, especially in developed countries like Canada. The maximum number of times humans can procreate is about once per year. Reproductive maturity begins on average at age 14.

12. The resistance factors that would be involved are space, food, temperature, and salinity. Those factors that did not play a role were predation and disease.

13. Graph of J-shaped curve



14. The quick increase in population exceeded the carrying capacity because food was supplied only once. The increased numbers of shrimp used all of the food and the population then fell down to zero.

15. Populations that grow beyond the carrying capacity may be affected by

    - an increase of ill health
    - scarcity of food supplies
    - the reproductive ability of adults decreasing

16. Populations may exceed a previous carrying capacity if the number of predators are decreased, if the amount of food increases, or if the climate becomes more favourable.

17. Any population requires various conditions for it to grow. If only one condition is at a level below the minimum tolerance, growth will be affected. In the brine shrimp investigation, a condition that was limiting was food availability. The food was so low that the population died out.

18. One factor that could have been in excess is the original salinity of the water. Brine shrimp prefer 5-6% saline solution, and, if the levels rise above this, then hatching rates will be decreased.

19. Two factors in the investigation that are density independent are the salinity and the temperature of the water.

20. Two factors that are density dependent are food supply and space availability.

21. The brine shrimp in the investigation were more affected by density-dependant factors, but in a natural environment the brine shrimp population size would also be regulated by various density-independent factors such as the salinity of the water.

22. By analysing the graphs you should have determined that the moose population, which is density-dependent and follows an S-curve, is a K-selected species. The mosquito population which is density independent follows a J-curve and is r-selected. A plant species that is K-selected would be a pine tree. They are large, relatively long lived, and produce few offspring. Most plant species are r-selected. An example is a sunflower, which produces many seeds and then dies.

23. r and K comparison chart

Category	r population	K population
environmental conditions	variable, many fluctuations	stable, few changes
population size	variable	constant
competition	not significant	intense
size of individuals	small	large
growth of young	rapid, little parental care	slow, parental care required
reproduction rate	high	low
survival during stress	adults die	young die
example species	ants	humans

Section 1: Activity 4

1. The duckweed will cover half of the pond on Day 29, when you only have one day to save the pond from destruction. If the duckweed doubles each day and covers the whole pond in thirty days, then on Day 29 it will have covered half the pond and it will double on Day 30 cover the rest.

2. The first dramatic change in human population occurred when some groups shifted from hunting and gathering to an agricultural-based lifestyle. This occurred around 8 000 B.C.

3. • **Review question 21**: The following three major factors have fueled the explosive growth in human population in the last 150 years:

    - the increased mechanization of agriculture, resulting in a much greater supply of food
    - the improvement in transportation, allowing better distribution of food
    - the decrease in infant mortality due partly to improvements in medicine, which allowed greater numbers of people to reach reproductive age

4. The Black Death devastated the European population in the 14th century. It is thought that one-third of the population died during the plague.

5. The type of growth has been exponential over the last 150 years.

6. In fact there are no other species that have the exact same growth curve as humans due to the fact that exponential growth is still occurring. View Figure 25.11 on page 585 for a possible example.

7. Humans appear to be following a J-curve. The curve has not begun to level off as it would in an S-curve.

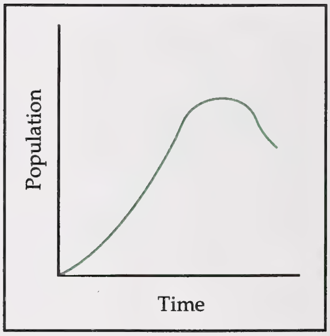
8. Fecundity does not begin until the age of 12 because the females have not yet reached puberty and entered sexual maturity.

9. According to the graph, females have the highest fecundity between the ages of 20 and 30.

10. About 17% of the babies are born to women 30 years of age.

11. Female fecundity falls to zero at age 48 because of menopause, which marks the end of a woman's fertile years.

12. If the fertility rate falls below 2.0 for an extended period of time, the population will begin to decline.



13. Two possible reasons that baby boomers might have to produce less children are a shift of societal factors based upon the status of women in society or that Canada is an industrialized country with a stable economy not requiring more people to fill the labour market.

14. - **Review question 20**: Population histograms show a population in terms of its age structure. They also show the proportion of males and females at a specific moment in time.

15. For zero population growth to occur, natality and immigration must be equal to mortality and emigration.

16. Canada's population with the fertility rate below 2.0 would have a declining population and would be represented by Age Pyramid C in Figure 25.20.

17. Sweden would have a stable population because new individuals are being born at the same rate that people are dying.

18. Mexico would have a growing population because new individuals are being born at a much faster rate than people are dying.

19. For countries that lost large percentages of the male population due to war, the age pyramid would have a smaller base due to the decreased number of births, and, of course, the section of the pyramid where these men died (20-30 years of age) would be dramatically diminished.

20. The problem with overpopulation in the developing world is a compounding of the consequences of excess: pollution, automotive congestion, and urban sprawl.

21. The problem of overpopulation in the developing world is the constant struggle for existence which drives people to do the following:
    - use farm land that is unsuitable for farming
    - send women further from their homes in search of firewood
    - deplete fisheries due to over-exploitation and contamination

22. Humans have been able to overcome the basic constraints of population growth by shifting to an agricultural base allowing the storage of food, being able to tap into the fossil fuel supply which drives industrialization, and developing medicines to control disease.

23. The negative effects of overcoming the constraints of population growth are as follows:
    - the beginning of serious deforestation
    - buildup of salt in irrigated lands
    - depletion of the finite supply of fossil fuels
    - the overpopulation of the planet

24. Mother Nature does not exhibit tolerance for exponential growth because, according to Thomas C. Emmel, "Exponential growth is abruptly terminated when the carrying capacity of the environment is surpassed and environmental resistance becomes effective more or less suddenly … they are very short lived phenomena…". Basically he predicts a rapid population decline.

25. Economist Julian Simon has rationalized human population growth by asserting that growth generates its own solutions mainly through inventiveness. Human creativity and technology will provide solutions to a population crisis.

26. The graph shows that when human population increases, so does the likelihood of another species disappearing forever. If the population of humans continues to rise, biodiversity on this planet will continue to decline as other species become extinct.

27. The bad news was that there is a predicted crash in both population and industrial capacity on the planet. The good news was that the Earth should end up with a carrying capacity of 6 million, which should be reached in 1995.

28. The following equation was developed to help explain the human population problem:

$$\text{Impact (on the planet)} = \text{Population} \times \text{Affluence} \times \text{Technology}$$
$$I = PAT$$

In order to decrease the impact population has on the planet, countries must reduce population growth and use affluence and technology in a responsible manner. Only then will the population problem be solved.

29. In Equation A, increasing *T* will cause an increase in *I*. In Equation B, increasing *T* will cause a decrease in *I*.

	Equation A	**Equation B**
Let $P = 2$	$I = PAT$	$I = \frac{PA}{T}$
$A = 4$	$= 2 \times 4 \times 6$	$= \frac{2 \times 4}{6}$
$T = 3$	$I = 48$	$I = 1.3$

Section 1: Follow-up Activities

Extra Help

1. The group of organisms that interbreeds to produce fertile offspring is called a **species**.
2. All living things live together in **populations**.
3. **Environmental biologists** study factors that affect winter survival, predation, and availability of nutrients.
4. The two main forms of population distribution are **uniform** and **clumped**.
5. Resource conservation and management has the ultimate goal of maintaining a **sustainable** population.
6. The most important aspect of population distribution is calculating a population's **density**.
7. The population of bison at Elk Island National Park is a **closed** population because of the two-metre-high fence that surrounds the park.
8. The four factors that limit the carrying capacity of bison at Elk Island National Park are **availability of nutrients**, **climate**, **space,** and **behavioural interactions**.
9. The growth curve for bison resulting from population management practices in Elk Island National Park is an **S-shaped** curve.
10. When overcrowding occurs in a closed system, natality **decreases** and mortality **increases**.
11. The type of growth curve for bison that would be evident if population management was not done in Elk Island National Park is a **J-shaped** curve.
12. The four ways that a population may change its numbers are **natality**, **mortality**, **immigration,** and **emigration**.
13. The two factors that caused the population of Richardson ground squirrels to decrease were **emigration** and **predation**.
14. The **carrying capacity** of Calgary was quickly reached in the late 1970s due to immigration based on a prosperous economy.
15. Dr. Stephen Herrero feels that the benefit of reintroducing endangered species into the wild is that it gives people **hope** and the knowledge that they are not always **harming** the environment.
16. The focus of Ellen McDonald's research on the Athabasca sand dunes is how **abiotic** factors affect the growth of plants.
17. **Food**, **energy**, and **space** are limiting factors that may cause humans to reach their carrying capacity.

Enrichment

1. The Earth is a closed system. As with all closed systems, there is a finite amount of materials. Dr. Suzuki's hypothesis is valid. Our population will be limited by one or a combination of factors. This environmental resistance can already be seen in some areas of the planet with disease, malnutrition, and pollution. The model of economic growth will result in the same scenario. Economic growth in one area of the Earth may increase the difference between rich and poor nations.

2. a. The experiment will have to be set up with two populations of voles within two enclosed areas. One population will have a higher number of voles; therefore, it will have a higher density. Sufficient food and water would be supplied for all individuals. Your results will consist of an examination of the number of young produced by the entire population as well as per female.

   b. Sufficient food and water are the fixed variables and must be present in order to maintain the health of the individuals. The size of the space must also be fixed. By fixing these variables, only the effect of density will be left to influence reproductive rate.

3. a. Curve I represents a population that has a low infant mortality and a relatively long life span. Curve II represents a population that has constant mortality throughout all age groups. Curve III is representative of populations of organisms that suffer high mortality of the young and the surviving individuals have a relatively long life.

   b. Curve I best represents human populations.

Section 2: Activity 1

1. - **Review question 27**: Succession is the gradual replacement of one community in an area by another community.

   - **Review question 28**: There are two types of succession. *Primary succession* is the term used to identify the development of vegetation on a previously sterile site. A good example would be a volcanic island. Secondary succession refers to the same process as primary succession, but it occurs on land which previously supported vegetation. A good example would be an abandoned farmer's field.

   - **Review question 29**: A climax community is a relatively stable community in which there appears to be no significant change in the composition of the vegetation after a period of succession. The climax community is dominated by the climax vegetation but also contains areas of vegetation representing earlier successional stages. A climax community can be recognized by the presence of relatively fewer species that are in a state of dynamic equilibrium. In a forest this would be large old trees of mostly just one kind such as spruce or pine trees.

   - **Review question 30**: Examples of human activities that lead to secondary succession would be forestry harvesting of wood, abandonment of agriculture fields, and setting of deliberate fires.

   - **Review question 31**: Succession proceeds in stages because the different stages require different soil and shelter conditions. These varying conditions are provided by the successive species of plants that establish themselves.

2. When a site is disturbed, it will return to an earlier seral stage. After the disturbance, the system will stabilize and then progress in the usual manner typified by the ecosystem.

3. The relationship that best exemplifies succession is interspecific competition. Plants in these areas are competing for the limited resources. Eventually one population of plants forms the dominant vegetation for the area.

4. The selective pressures may cause evolution and speciation to occur. Natural selection will determine which individuals in a gene pool survive.

5. a. iv b. iii c. i d. ii

6. - **Procedure question a**: The algae are producers and are the first organisms to produce nutrients by photosynthesis. They are concentrated on the ice surfaces that receive the most sunlight and in melted water at the edge of the glacier.

   - **Procedure question b**: The melting of the glacier carries minerals and dead algal matter into the lower depressions between the rocks. These low-lying areas make an ideal location for the accumulation of soil. Seeds will germinate and plants will grow in these enriched pockets.

   - **Procedure question c**: Because the microbes can fix nitrogen from the air, these plants can live in soils that contain little nitrogen. The nitrogen-fixing microbes and the plant exhibit a mutualistic relationship. The plant is supplied with nitrogen and the bacterium is provided a place to live and a source of carbohydrates.

   - **Procedure question d**: Diagram (iv) is dominated by small herbaceous shrubs and trees. Diagram (v) shows the dominant vegetation as hemlock and aspen. During the time between the two photographs, the hemlock and aspen have been able to out-compete the shrubs. The landscape has deeper, richer soil; more shade; and more moisture.

   - **Procedure question e**: The mountain avens die and decompose, adding organic matter to the soil. After a number of years, more organic matter adds nutrient and the amount of soil found in the area increases. The cottonwood shrubs do not make their own nitrogen, and therefore they require a higher nutrient soil before they can colonize. The thicker richer soil established by the mountain avens also provides an anchor for the roots of the shrubs.

7. The later stages of succession have the greatest biomass. As soil quality improves, larger plants begin to grow. These plants can support more primary consumers, and hence more secondary and tertiary consumers.

8. - **Application question 1(a)**: In community (vii) there are more producers to support a greater number of consumers. This community has a greater available food source.

   - **Application question 1(b)**: Community (vii) will have the greatest diversity of organisms. A mature forest can support consumers at ground level and in the trees. The taller and larger the tree, the more diverse the habitat.

   - **Application question 3**: As trees grow, less sunlight reaches the forest floor. Decomposing leaves form a blanket which further reduces water loss from the soil by evaporation and adds organic matter which improves soil quality.

9. This is an example of primary succession because it is occurring on land not previously covered by vegetation.

10. Immediately after being abandoned, annual weeds and other pioneer species will invade the field. Grasses and perennial herbs will later make an appearance. Approximately 10 years later, aspen shoots will be extending from the field edges. Eventually spruce trees will grow in and return the field to forest.

11. The field would be completely gone and would be covered with aspen or spruce. Due to increased shade, moisture-loving species such as birch would have appeared. The site should have taken on the appearance of a mixed boreal forest common to this region of Alberta.

12. Chaos theory attempts to put order to apparently random events.

13. Biological systems are exceedingly complex in many circumstances. This degree of complexity lends itself to analysis through the application of chaos theory.

14. Depending on the conditions, the trees probably would have been killed by the fire. The canopy would have opened up, so grasses and fireweed could shoot up rapidly becoming the dominant vegetation. The roots of the aspen trees would send up shoots, and in several years a dense growth of aspen saplings will have taken over the site. As spruce do not grow from their roots, it may be decades until they appear. This apparent random event upset the order of succession. Further studies on this site might show that every 120 years a major fire has taken place. What appeared to be a random event could be part of a regular pattern. The time scale of observations has to be increased. As you can see, there is no certainty in predicting complex events such as succession. The more complex the issue, the greater the role chaos theory may play in providing an explanation.

Section 2: Activity 2

1. These trees would be able to release their seeds to the disrupted site immediately. If they germinate first, they will be at a competitive advantage.

2. One would expect most of the trees to belong to one age class. As the pine seeds are released during a fire episode that kills the adult trees, the ages of the trees should be very close as the seed would have germinated at the same time.

3. Secondary succession would normally follow a forest fire. That is, succession where there has been a previous vegetation cover and where soil is present.

4. Two forest species, aspen poplar and jack pine, are already present in Year 1, so the forest will regenerate.

5. Radical changes in abiotic factors have occurred, for example, high light intensity, soil change, death of parent species. Tree species development is slow and long term. This creates a new niche for the invasion of rapid-growing annuals and perennials requiring rich soil and light.

6. Saplings have sprouted (clones) from the parent root system. This is the usual way poplar species reproduce. Their rapid development prevents the development of other tree species.

7. Spruce (plus a few poplars in B) was the dominant species.

8. Jack pine is a fire-adapted species. Its cones open up to release seed only when highly heated such as in a forest fire. Jack pine was present in the original forest.

9. Moisture and sunlight (shade) differ between A and C. The tree species influence soil composition (conifers create acid soil) during leaf loss and also control the level of surface light. Herbaceous plants have their own specific requirements and the two areas have differing environmental characteristics.

10. Zone A is at the bottom of the hill and thus there are differences in the moisture of the soil. Drainage patterns would lead to drier soil/environment on the slope and upper ridge. As different vegetations appear in each zone, they in turn help to increase the differences between the zones. Conifer needles decompose slowly and account for acidic soil whereas deciduous leaves decompose more rapidly increasing soil nutrients.

11. It is possible that some of the white spruce seeds survived the fire. More likely the seeds were carried in by wind or by animals such as squirrels from other spruce trees nearby. Spruce grows very well under a canopy of jack pine.

12. Succession has progressed to a climax stage in Zone A and is still occurring in Zones B and C. Zone A is dominated by aspen poplars as a climax species in this zone. No other type of tree is replacing the aspens. Zone B is at the seral stage. If Zone B remains at the jack pine stage it could be at a climax stage, but spruce may spread in. Zone C is showing a substratum of spruce as opposed to a canopy of jack pine. Spruce will usually take over jack pine over time.

13. Predictions of appearance of study site in 50 years: Zone A may likely be similar. Spruce could, and often do, invade an aspen poplar area. Because poplar clone, the area may perpetuate an aspen poplar climax community. Zone B will probably be a spruce forest with the odd jack pine and possibly a poplar or two. The dryness of the slope would tend to delay the first forest seral stage until sufficient soil was formed to provide a base for the climax spruce to invade. Zone C will probably be a very mature spruce forest which would remain the climax forest unless disturbed by another natural phenomenon.

14. There was a rapid growth in the first few years after the fire because the soil was enriched by the ash from the fire and the area was opened to light. Since the vegetation was destroyed by the fire, the area was wide open to the invasion of sunlight-requiring plants.

15. Since the vegetation and cover continuously change, the animal life supported by these primary producers must change accordingly.

16. The greatest variety of animal life would be expected somewhere in the first 10 or so years (+/-). The greatest vegetation development occurs at this time, particularly the high-energy food typical of herbaceous plants. As the forest matures, shading reduces the herbaceous and ground-level plants and there is less available food and thus fewer animals.

17. The pattern of succession will be different as certain species need to be stimulated as a result of the fire. As discussed earlier, lodgepole pines and jack pines require intense heat to open their cones. Removal of these trees by logging will not stimulate them to grow back.

18. a. The replanted seedlings represent a later seral stage of succession. The plants that normally dominate (grasses, shrubs, and aspen) after forest has been removed may outcompete the planted trees for vital nutrients and moisture. Conditions may be too sunny for the shade-loving climax seedlings. Intensive care may be required to insure the success of the replanted area.

    b. If the area is not replanted with seedling and is left to regenerate on its own, the natural order of succession will take much longer as the earlier seral stages have to prepare the area for the climax vegetation.

19. The amount of heat required to open the cones varies in order to ensure that some seeds are not damaged by the fire. A low temperature fire that kills the trees may not open all of the cones. Conversely, a high temperature fire may injure some of the seeds, so some variation is most likely to release seeds.

20. If the cones got too hot, they may begin to burn. These high temperatures would kill the seed. Long pine needles burn hot and fast. Most flames occur at some distance from the cones. This just melts the outer resin.

21. The seeds are winged to aid in dispersal. The greater the spread of the seeds, the better the opportunity that some of them land in habitat suitable for germination.

22. This material could be used for biologically sealing containers. The heat-sensitive substance could be used for temporary bonds. The possibilities are limited only by imagination.

23. The cones of the two trees appear different. The cone of the young trees are open, while the cones of the mature trees are sealed.

24. The young trees with their open cones may be able to release seeds into nearly the same conditions that they themselves germinated in. They need not wait for a forest fire. In this way the jack pine forest spreads more quickly.

Section 2: Activity 3

1. One side of the ravine is forested with spruce trees, while the other side has mostly aspen trees and small shrubs.

2. The amount of rainfall that these two areas receive should be almost the same. They are so close together that it is a reasonable assumption. A rain gauge at each site would determine if this is in fact true.

3. Forested regions usually require a higher amount of moisture. Trees have a higher water requirement than grass.

4. The regions being in such close proximity should receive the same amount of precipitation. If this is assumed, then what happens to the moisture after it falls is the difference. The south bank faces north, and is shaded; therefore, it does not lose its moisture as fast as the north bank which faces south. The south-facing slope must be losing moisture at a higher rate.

5.

Factor	Effect on Soil Moisture
Slope	The steeper the slope, the greater the chance that any precipitation that falls will run off.
Air and soil temperature	A higher air temperature allows for a greater rate of evaporation.
Light intensity	More available light increases the temperature and increases the rate of evaporation.
Wind speed	Greater wind speed will increase the rate of evaporation.
Relative humidity	Air with a higher moisture content will have a lower rate of evaporation.
Percolation rate	Soil that has a greater ability to absorb moisture will take in more when it is available.
% Soil moisture	This is an indication of a sample's moisture-holding capability.

6. Observations data will vary. A sample has been provided for you. Kennedale Ravine May 15, 1993 Sunny.

Factor		Site 1 South Facing	Site 2 North Facing
Attitude		150°	343°
Slope		25°	17°
Light Intensity		55 lux	8.5 lux
Air Temperature	Surface	26°C	15°C
	2 m above surface	15°C	15°C

Factor		Site 1 South Facing	Site 2 North Facing
Soil Temperature	Surface	20°C	6°C
	10 cm below surface	15°C	5°C
Relative Humidity	Surface	53%	71%
	2 m above surface	47%	61%
Wind Speed		17 km/h	6 km/h
% Soil Moisture		13%	32%

7. You should include the topics discussed in the following paragraph. The close proximity of these two sites are all that they have in common. Due to its orientation to the sun, the south-facing bank receives much more light. This higher degree of insolation (amount of light) creates a microclimate that is drier than the surrounding flat areas. Conversely the north-facing bank receives less light and the microclimate there is more moist. This higher amount of moisture favoured the growth and development of tree seedlings. Once these seedlings become established, further shading of the site only continues to increase the available moisture. This positive feedback continues until the north-facing side develops a forest while the south-facing side supports only those plants hardy enough to survive the harsh, more dry environment.

8. A different pattern of succession will have occurred at either site.

North-Facing Bank (South bank of ravine)

grasses, fireweed → herbs and shrubs → tree seedling → mature forest → climax forest

South-Facing Bank (North bank of ravine)

grasses → grasses and herbs → grasses and shrubs → aspen trees

Section 2: Activity 4

1. The tack stimulates pain receptors in the skin of the foot. The pain receptors in turn stimulate a sensory neuron, which carries an impulse up the leg to the spinal cord. In the spinal cord an interneuron is stimulated. The impulse is transferred to a motor neuron, which in turn stimulates muscles in the leg, and to a spinal neuron, which carries the impulse to the brain. The leg and foot jerk away from the point of impact and the brain recognizes the event.

2. Visual stimuli signalled danger and activated Penny's sympathetic nerves in her autonomic nervous system. This nervous system increased her heart rate initially and stimulated the adrenal glands to release adrenaline. Adrenaline increased the strength of the muscle contraction in her hands so much so that the muscles ached afterwards. Adrenaline remaining in her bloodstream also maintained an accelerated heart rate even after the danger had passed.

3. a. Since the corpus luteum, which is part of the ovaries, will also be removed, estrogen and progesterone levels will fall. Thus early in the pregnancy the endometrium, which depends on these hormones, will degenerate.

   b. If the endometrium degenerates, the developing placenta will also degenerate and the pregnancy will end in a miscarriage.

4. a. The twins must have resulted from a single ovum that divided after fertilization.

   b. The twins would be paternal, coming from a single egg.

5. Nondisjunction in mitosis will create a cell with an abnormal number of chromosomes. In mitosis, or cell division in body cells (somatic cells), this will create an abnormal cell. This abnormal cell may die or cause disease such as cancer. The condition will be initially limited to the tissues of which the cell is part. Nondisjunction in meiosis will create an abnormal chromosome number in a sex cell (gamete) such as a sperm or egg. If this gamete later becomes a zygote by fertilization, all cells of the developing embryo will reflect the abnormal chromosome number. This may cause a condition such as Down syndrome, Turner syndrome, or others.

6. Let the genotypes and phenotypes be as follows in an example of incomplete dominance controlling flower colours.

Genotype	Phenotype
RR	red
Rr	pink
rr	white

Monohybrid parents = *Rr* × *Rr* or Pink × Pink

Punnett square

	R	*r*
R	*RR* (red)	*Rr* (pink)
r	*Rr* (pink)	*rr* (white)

$$\text{Red} = \frac{1}{4} \text{ or } 0.25$$

$$\text{Pink} = \frac{1}{2} \text{ or } 0.5$$

$$\text{White} = \frac{1}{4} \text{ or } 0.25$$

H-W Formula

$$p^2 + 2pq + q^2 = 1$$

$$p^2 = RR = 0.25 \text{ (red)}$$

$$p = \sqrt{0.25}$$

$$= 0.5$$

$$q^2 = rr = 0.25 \text{ (white)}$$

$$q = \sqrt{0.25}$$

$$q = 0.5$$

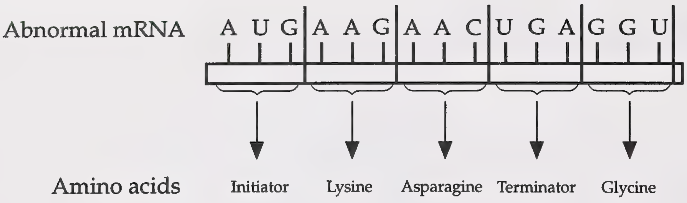
$$2pq = 2(.5)(.5)$$

$$= 0.5 \text{ (pink)}$$

$$p^2 + 2pq + q^2 = 0.25 + 0.5 + 0.25 = 1$$

Both the Punnett square and the H-W formula predict that the frequency of phenotypes will be $\frac{1}{4}$ or 0.25 red, $\frac{1}{2}$ or 0.5 pink, and $\frac{1}{4}$ or 0.25 white.

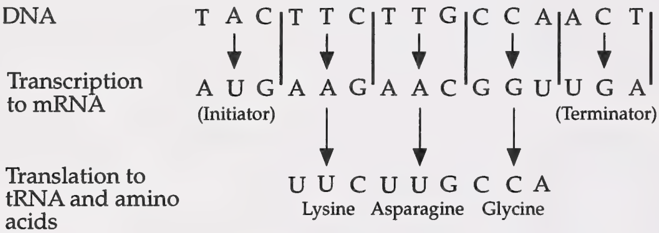
7. a.



The mutation seems to be the location of the terminator codon before the codon for glycine. In the DNA sequence, the mutation will be TAC TTC TTG ACT CCA

↑
terminator

b. The mutation may be corrected by switching ACT and CCA. The new sequence will be as follows:


DNA
T A C | T T C | T T G | C C A | A C T
Transcription to mRNA
A U G | A A G | A A C | G G U | U G A
(Initiator)
(Terminator)
Translation to tRNA and amino acids
U U C U U G C C A
Lysine
Asparagine
Glycine

8. Natural selection may place environmental pressure on certain genotypes. In a particular environment a certain genotype may be at an advantage. Individuals heterozygous for sickle-cell anemia are resistant to malaria. They neither die of malaria nor of sickle-cell anemia. Individuals who are homozygous for sickle-cell anemia usually die of the disease. So the heterozygous genotype is selected for by the environment while the homozygous genotype is selected against. So long as the environmental pressure of malaria is present, the advantage of the heterozygous condition remains.

9. Total time = 2.5 h. 70% machine scored = 1.75 h (multiple choice and numerical response)
30% (written response = 0.75 h.)

Section 2: Follow-up Activities

Extra Help

1. a. primary
   b. secondary
   c. microclimate
   d. seral
   e. pioneer
   f. climax
   g. disruption

2. a. iv
   b. ii
   c. i
   d. iii

3. a. Grasses, fireweed, and aspen have an advantage in regrowing after a disturbance because they have the ability to grow back from roots in the ground and prefer lots of sunlight. Within weeks after a fire, these plants will be thriving on the opened up area. Other plants will have to colonize the area from seeds and this takes longer.

   b. Jack pines and lodgepole pines depend on fire to open their cones and release their seeds. These seeds will replant the area days after the fire, allowing them to germinate first and establish themselves before other plants.

4. Snowshoe hares preferred the early stages of regrowth of mixed-wood forests.

5. These types of habitats occur when a mature forest is either logged or burned.

6. Aspen trees mature in 30-40 years, while spruce trees mature in 80-100 years.

7. Aspen trees appear first because they can grow from roots left in the ground. This allows them to grow much faster.

8. Stand tending will speed up the successional development of the forest. Spruce trees that would normally be very slow developing may be advanced years or even decades by the cutting back of the fast growing aspens. The competitive advantage the aspens have has been removed.

Enrichment

1. The development of life will appear more quickly on the island that is closer to the mainland. Organisms from the mainland or the seeds or spores of plants will be able to reach the near island easier. The pattern of succession should not be significantly different, it will just be slower in the arrival of certain organisms. In some cases, the extreme distance of the far island may make it impossible for some species to ever arrive there naturally.

2. a. Most forest fires are started by lightning strikes.

   b. The motives behind fighting forest fires are economic. Investments made in infrastructure (human-made structures such as buildings and roads) need to be protected from damage by fire. The other reason for fighting forest fires is to protect the wood so that it can be used for lumber production and pulp and paper.

   c. Wood Buffalo National Park has a mosaic of environments. These represent various stages of succession.

   d. If the nutrients were not returned by a fire, the organic matter would remain in the dead trees and the nutrients would stay locked in that matter possibly for years. As time passes, the nutrients available to the ecosystem would be reduced and the productivity would be low. These are characteristics of a climax community.

   e. 5% of the seedlings usually form the mature forest.

   f. Grizzly bears require a large and varied food base. Alpine meadows that supply these foods are maintained by fire. Trees do not encroach on these meadows as a result of fires and new meadows will be created when a forest burns.

   g. The pine trees must have a short exposure to a high temperature. This will melt the resin that seals the cones. If the trees are killed by pine beetles, the cones will remain unopened and the seeds locked in.

   h. Spruce and aspens are the usual trees that replace insect-killed pines.

   i. The pines created a microclimate that was moister due to the shade that they provided. This moister situation allowed for spruce seedling to germinate and start growing.

- j. The mature forest have reduced the amount of forage available to the herbivores by shading the ground. With a lesser amount of food available, fewer animals can be supported. The policy of suppressing fires encouraged the growth of mature forests resulting in fewer animals.
- k. Fires set in the park will mimic situations that used to occur naturally. Controlled burns can be planned to insure they have the desired effect without damaging the parks facilities. Creating the mosaic pattern of environments will increase species diversity and prevent the possibilities of large uncontrollable fires. Finally, research about fires can be continued as one knows where the fires are going to occur.

3. The Pine Ridge Nursery can be contacted by phone at 656-4130.

Science Skills Spreadsheet

You may reproduce this spreadsheet as required for use in this course.

CHARTING GROWTH IN SCIENCE SKILLS														
Feedback From Assignments			Initiating and Planning		Collecting and Recording		Organizing and Communicating		Analysing		Synthesizing and Integrating		Evaluating	
Module	Section	Question	Self	Teacher	Self	Teacher	Self	Teacher	Self	Teacher	Self	Teacher	Self	Teacher

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Biology 30

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Module 7

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